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Materials & Methods

THE METALWORKING INDUSTRIES' ENGINEERING MAGAZINE

Alloys Made by Electric Ingot Process

Synthetic Finish for Ferrous and Nonferrous Metals

Ceramic Materials for High-Temp Mechanical Parts

Cyclic Annealing of Steel Forgings

Metallic Titanium is Light, Strong, Durable

Centrifugal Casting for Iron Piston Rings

Open-Butt Pressure Welding of Steel

Annual Engineering Review

MATERIALS & METHODS Manual No. 33

January
1948

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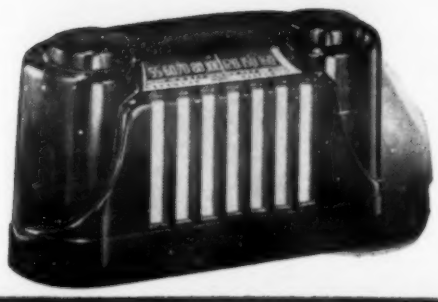
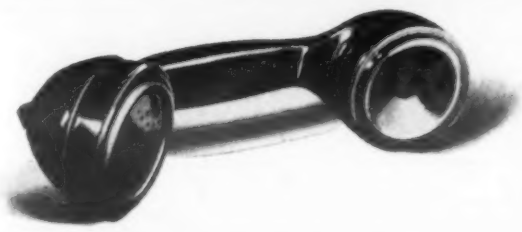


LOW-COST PRODUCTION

ELECTRICAL STRENGTH



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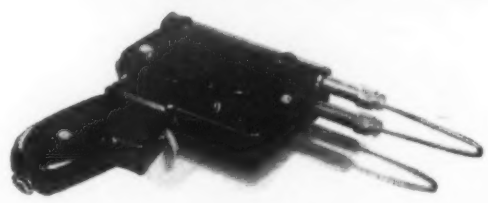

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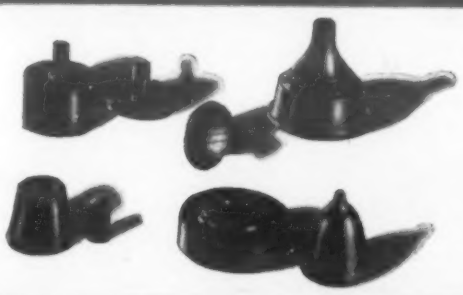

CHEMICAL RESISTANCE

SPECIAL PROPERTIES

DUREZ — PHENOLIC RESINS — MOLDING COMPOUNDS; INDUSTRIAL RESINS; PROTECTIVE COATING RESINS

PHENOLIC PLASTICS that fit the job

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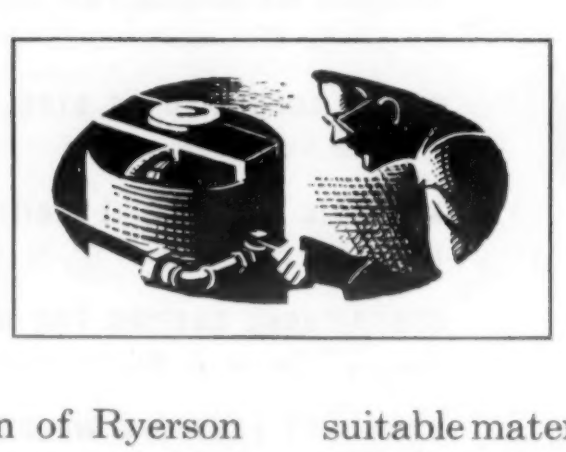
HOW TO GET . . . .

Exact Mechanical Properties in Alloy Steel from Stock



Most steel buyers are accustomed to specifying alloys on the basis of analysis alone. But there's a better, surer way of buying that's gaining more followers daily—specification of Ryerson alloys by analysis *and* minimum hardenability requirement. Either one alone isn't enough. Together they give double assurance that your steel will measure up to performance demands.

You can order this way from Ryerson because we test every heat of annealed and as-rolled alloy in stock. Establish the heat treatment response for every shipment by end-quench hardenability tests. Then, when you specify the mechanical properties you must have after heat treating, we select bars that, on the basis of actual tests, will do the job.

This system of purchasing can effect important savings for your company. It protects against expensive product failure and practically eliminates the possible necessity of replacing unsuitable material. Ryerson assures delivery of alloy steel that will amply meet your minimum hardenability requirements.

And to prove that you can get the desired performance, we send a Ryerson Alloy Report with every shipment. Charted test results and mechanical properties interpreted from them confirm the steel's hardenability and guide you in obtaining the desired heat treatment results.

Hardenability is nothing new with Ryerson. It's been a Ryerson service for ten years now. If you have yet to order on this basis why not investigate the advantages? Thousands of tons of tested Ryerson alloys are awaiting your call.

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RYERSON STEEL

The MATERIALS OUTLOOK...

LEAD WILL BE EASIER — Lead metal, which has had a long period of tight supply position with only a slight let-up, looks more favorable for the long-range view than most other metals. This is not because of greater production, but because of the trends towards changed uses. Storage battery plates have been responsible for the biggest consumption in the United States, with paint pigments next, and then high-octane gasoline. These three uses have accounted for about 60% of lead consumption. Present trends are toward the cadmium-nickel alkaline storage battery developed in Europe and improved here; toward greater replacement of lead pigments with titanium oxide; and, toward lead-less high-test gasolines. The change-over will not be sudden, but will be rapid enough to ease the supply situation for other mechanical uses.

SAVE ON YOUR TIN USES — The story of tin is a sad one. There simply is not enough tin anywhere in prospect to meet demands of a free market. Forecasts made by the Tin Study Group last spring turned out to be duds; one Washington authority called them "arbitrary hypotheses equivalent to mere assertions." The situations in the East Indies and China are bad and are expected to be worse. The prospects for increased tin production in Bolivia and Africa are not bright. The United States Government cannot put off stockpile purchases much longer, so that large tonnages of tin may be removed from the market for stockpiling in 1948. It would be wise to examine uses of tin in solders, bearings, bronzes, and white metals.

TIGHT SUPPLIES IN 1948 — Manufacturers can expect annoying shortages all across the board in 1948. The Marshall Plan for aid to Europe is stated to require less than 5% of our production. But averages are deceptive, and some items are going to be hit hard. For example, exports will take more than 20% of various kinds of rolled steel and sheet already in short supply. Exports of sheet steel have been running about 30,000 tons a month. We used to think of 70% of capacity as a normal operation for steel mills; today, operations are around 95% of capacity, too close to capacity to avoid delays in delivery with the best planning. The already announced new facilities, plus those to be announced soon, will not make an easy supply position for steel within the year.

ALUMINUM DEFICIENT ALSO — Right now many designers would be pressing for the use of aluminum if the purchasing departments could assure an easy market. And that is not confined to the car-building industry; it covers a wide range of products. Aluminum sheet, though relatively more plentiful than sheet steel, will not be in easy supply even when the new sheet mill gets going in the West early in 1948. Aluminum ingot itself is not up to real demand, and there is now serious talk of the Government buying ingot for stockpiling.

ZINC POSITION IS BETTER — Zinc has been in fairly adequate supply in all grades in spite of the stoppage of Government subsidies, and the supply position for 1948 appears quite good. Imports of zinc in ore and metal have been averaging about 5% above the 1946 average. Stocks have been gaining a little even with the 1947 consumption of slab zinc 18% above the prewar average. Biggest use of slab zinc continues to be for galvanizing, with 43% being used for that purpose in 1947. The steel people say that the aluminum industry is welcome to the corrugated sheet business anytime they are ready to take it over, but there isn't enough aluminum available to take that business. But even with a continued big use of zinc for building sheet, no dire shortage of zinc metal is in sight.

CAUSTIC ALKALI CONTINUES SHORT — Government experts estimate that caustic soda supply will not balance demand before the middle of 1949, in spite of any presently projected plant expansions. The mechanical industries know caustic best through its use for cleansing baths, but caustic soda is a raw material and processing material in so many industries that its shortage will affect innumerable products.

Automobile bumpers are austempered in mass production in this Ajax mechanized unit. Fast salt bath heating cycle saved 2/3 floor space required by radiant heat furnace.

Martempering bearing races (1½" thick x 18" diam.; through-hardened to 57-61 Rc.) in salt baths eliminated die quenching equipment and reduced distortion. Savings in final grinding operation alone quickly repaid investment.

For your tough heat treating problems . . . Investigate
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The Ajax Isothermal Heat Treat Process for martempering, austempering and other interrupted quenching operations has replaced the conventional quench and temper method in hundreds of installations for a great range of products.

- **Treats finish-machined parts**
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- **Eliminates quench cracks**
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- **Increases toughness and ductility**
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Write for Ajax Isothermal Quench Furnaces for Martempering and Austempering. Bulletin 120

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Not mere claims — but facts backed by plenty of proof! If you do any heat treating, it will pay you to investigate the latest Ajax engineered developments. Ajax will not only recommend suitable equipment — but, by actually treating your products in our Metallurgical Service Laboratory, will demonstrate exactly what results will be obtained. You be the judge! Write today!

The World's Largest Manufacturer of Electric Heat Treating Furnaces Exclusively

AN EDITORIAL

Have a Happy '48!

Now the Christmas days are over,
and the holly's put away—
How supinely we've discarded
all the spirit of the Day!

Here we're back amid our blueprints
and our furnaces and tools
Frowning fiercely at our fellows
and the things they do, like fools:

How they make mistakes on drawings,
specify a kind of steel
That won't draw or turn or harden
(minus a Divine appeal)!

Or suggest we find a metal that is ductile,
tough and strong,
Free-machining, beats corrosion—
and whose price is but a song.

Ask us for a plated coating;
anything will be all right
Which is thin, outwears the diamond—
and remains forever bright!

Then request a low-cost method—
cast or forged or stamped or spun—
That must handle complex shapes
at plus or minus three-naughts-one.

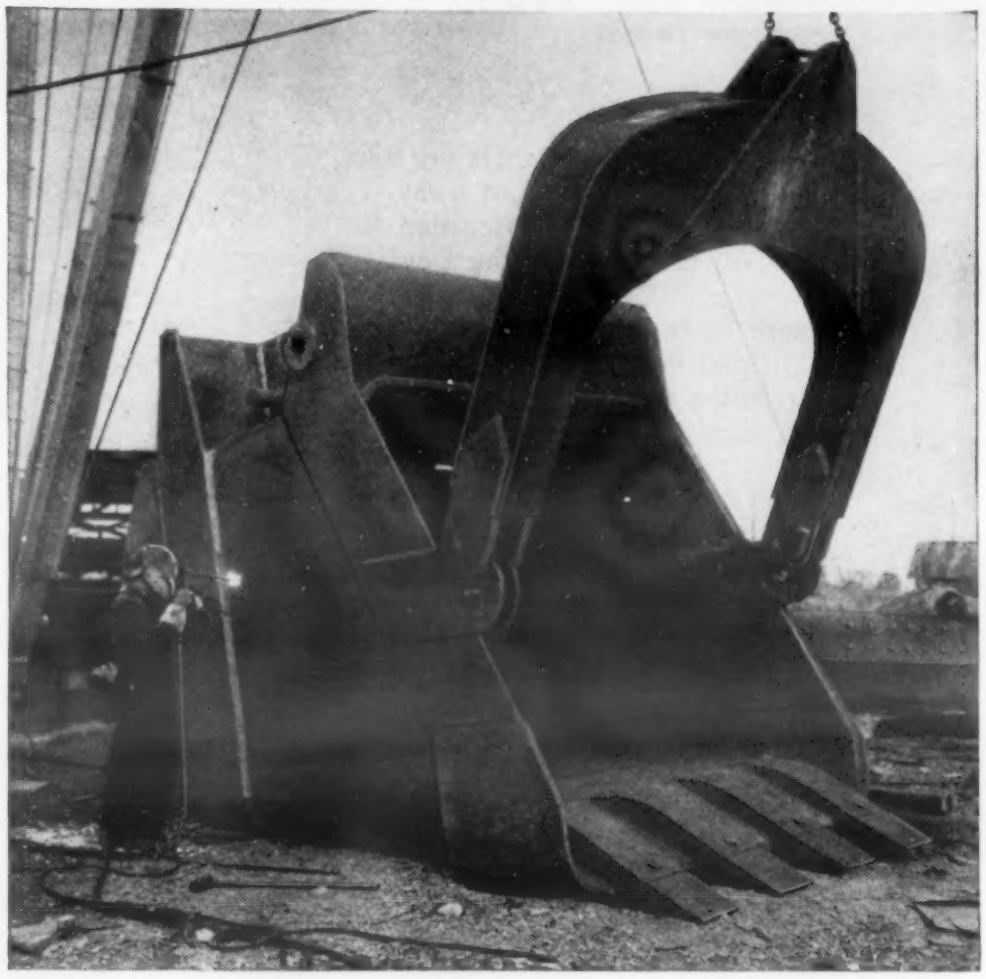
Pity that these peccadilloes
in the Providential plan
Add their trifle to the total
inhumanity to man!

Marshall has much bigger problems
(Truman has his Stassen, too).
Would your headache be much better
if their worries fell to you?

Every year your working problems
change, but don't evaporate.
Put them in their proper places:
Have a happy '48!

FRED P. PETERS

This Bucket holds 77% MORE ..yet WEIGHS 23% LESS



This stripper bucket is another example of how large weight reductions can be made with Hi-Steel. Yet it welds as well or better than ordinary structural steel, and it can be cold formed, hot worked, and machined just as easily, so that the most economical fabrication processes can be used.

when made of INLAND HI-STEEL

The capacity of this stripper bucket was increased 77% while its weight was reduced 23% by the use of low-alloy, high-strength, Inland Hi-Steel. The bucket was originally made of cast metal and weighed 47,000 lb. Its capacity was 13 cubic yards. By designing to take advantage of the great strength of Hi-Steel, the weight of the bucket was reduced 11,000 lb and its capacity increased to 23 cubic yards.

Inland Hi-Steel has nearly twice the working strength of ordinary structural steel, 50% greater ability to stand up under impact loads, and a marked resistance to vibration. In addition, it has about five times the atmospheric corrosion resistance and is far more resistant to abrasion.

Unfortunately, the present demand for Hi-Steel continues to exceed the supply. To make larger tonnages available to you, other steel companies have been licensed to make this superior product.

Write for Engineering Bulletin No. 11, INLAND STEEL CO., 38 S. Dearborn St., Chicago 3, Ill. Offices in: Davenport, Detroit, Indianapolis, Kansas City, Milwaukee, New York, St. Louis, St. Paul.

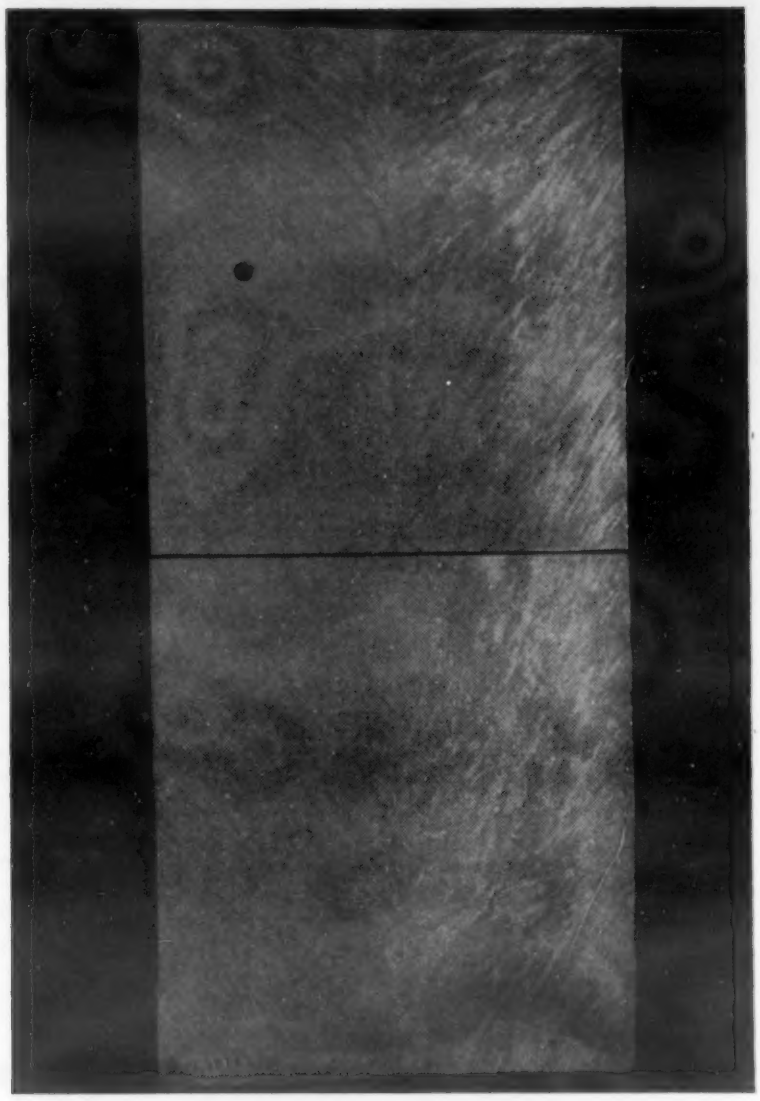
AVERAGE PROPERTIES OF INLAND HI-STEEL
compared with those of ordinary structural steel

	INLAND HI-STEEL	ORDINARY STRUCTURAL STEEL
TENSILE PROPERTIES (¼" Plate)		
Yield Point	62,000 lb per sq in.	33,000 lb per sq in.
Ultimate Strength	74,000 lb per sq in.	66,000 lb per sq in.
% Elongation in 8 in.	24%	25%
ENDURANCE LIMIT		
Fatigue Strength	49,000 lb per sq in.	33,000 lb per sq in.
IMPACT RESISTANCE (Charpy Impact in Ft Lb) Temperature		
80 degrees F	55.3 ft lb	36 ft lb
32 degrees F	43.1 ft lb	33 ft lb
15 degrees F	39.5 ft lb	29 ft lb
0 degrees F	36.3 ft lb	26 ft lb
—10 degrees F	36.8 ft lb	16 ft lb
—25 degrees F	33.7 ft lb	6 ft lb
—50 degrees F	30.4 ft lb	2 ft lb
PHYSICAL PROPERTIES FOR RIVET DESIGN		
Shear Strength	66,000 lb per sq in.	44,000 lb per sq in.
Bearing Strength	115,000 lb per sq in.	95,000 lb per sq in.

INLAND HI-STEEL meets the requirements of SAE Specification 950

INLAND STEEL

Materials & Methods
JANUARY 1948



A macro-section taken along the longitudinal axis of an electric ingot showing the absence of pipe and shrinkage cavities. The ingot is a 16 chromium-25 nickel-6% molybdenum alloy and is 20 in. long and 9½ in. in dia.

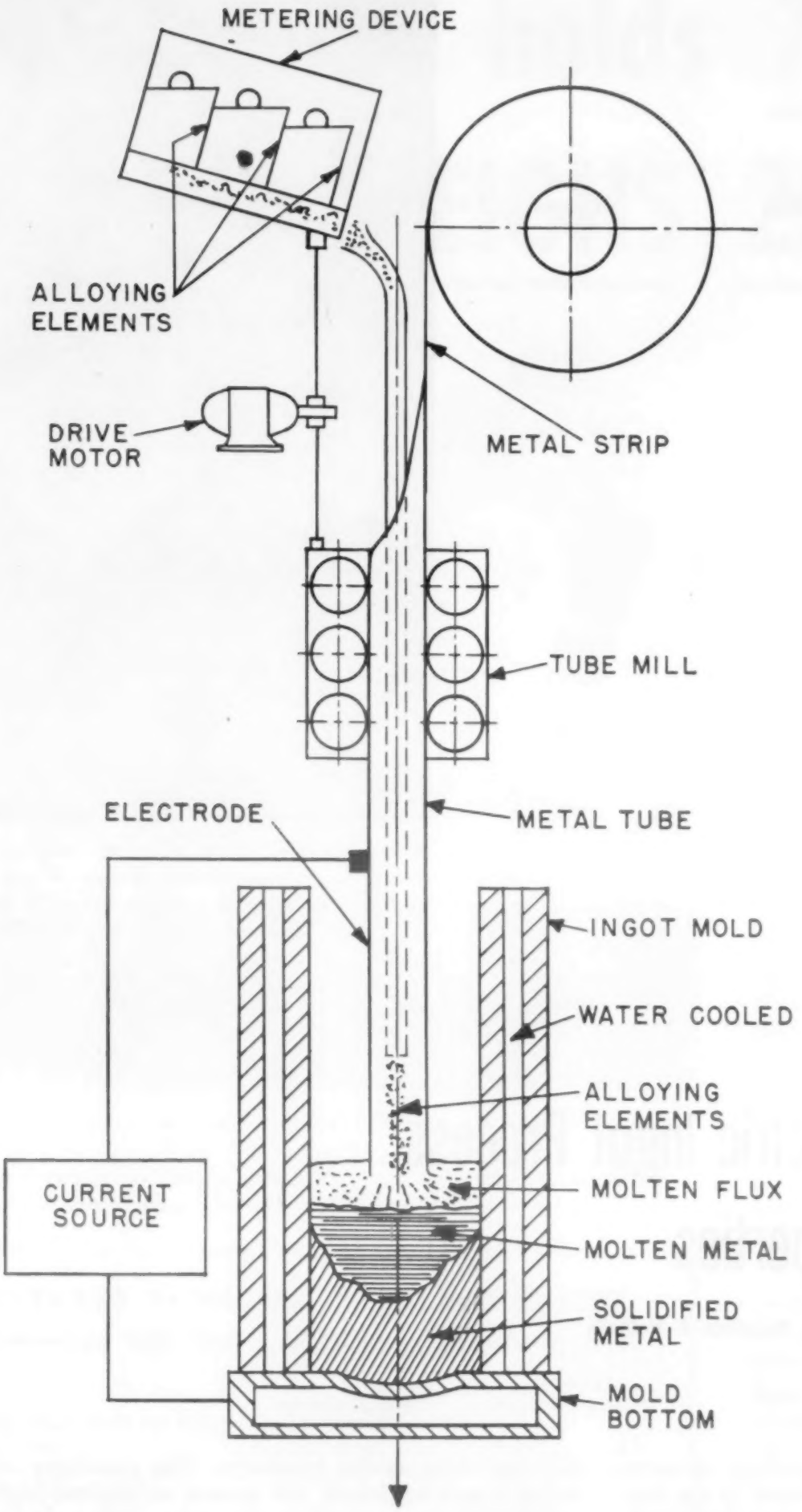
Alloys Made by Electric Ingot Process Have Improved Properties

by H. R. CLAUSER, Associate Editor, Materials & Methods

THE INTRODUCTION OF ELECTRIC melting furnaces some years ago is generally considered as the first significant step towards producing extra high quality metals and alloys. What may turn out to be an advance of similar significance is the development of the electric ingot process by the M. W. Kellogg Co. This process produces specialized alloys not having many of the defects inherent in alloys made by conventional melting practices; they have highly uniform compositions and structures which result in a number of improved performance properties.

The electric ingot process is really an outgrowth of the intermelting or "Kelcaloy" method of making stainless clad steel, which was developed by M. W. Kellogg about twelve years ago. The possibility of using a modification of this process to produce high grade alloys began to be investigated as early as 1935.

Many of the defects common in steel produced by the usual means can be eliminated by a new process which results in alloys free of segregation and having better properties.



Schematic sketch showing principal characteristics of the electric ingot process.

Development work progressed steadily, and during the war considerable tonnages of stainless steel for welding rods and high-speed tool steel were produced.

The Process

The accompanying schematic sketch shows the essential features of the process. Material in strip form is fed through a tube mill where it is formed into a continuous tube. This tube is fed down into a water-cooled ingot mold which is, in effect, an electric furnace with the tube serving as the electrode. The arc that is struck melts the tubing in the mold.

There is another tube of smaller diameter that extends part way down through the larger tube. The second tube is connected with a "metering" device which supplies predetermined amounts of the alloying ingredients and a flux to the system. The flux is some-

times added separately. The alloying ingredients and flux fall from the feeding tube into the arc and are melted along with the tube. The flux upon melting floats to the top and serves as a protective cover between the atmosphere and molten metal. A thin coating of flux also sticks to the sides of the mold and permits easy removal of the ingot.

The process is quite flexible. There is no specific limit on the length of ingot that can be produced, but for practical reasons, the lengths at present vary from 6 in. to 6 ft. Translation from pilot plant operations to volume production can be made directly without any compensating factors being involved. Also, small heats of 25 to 50 lb. can be produced in the same equipment that is used for ingots many times larger.

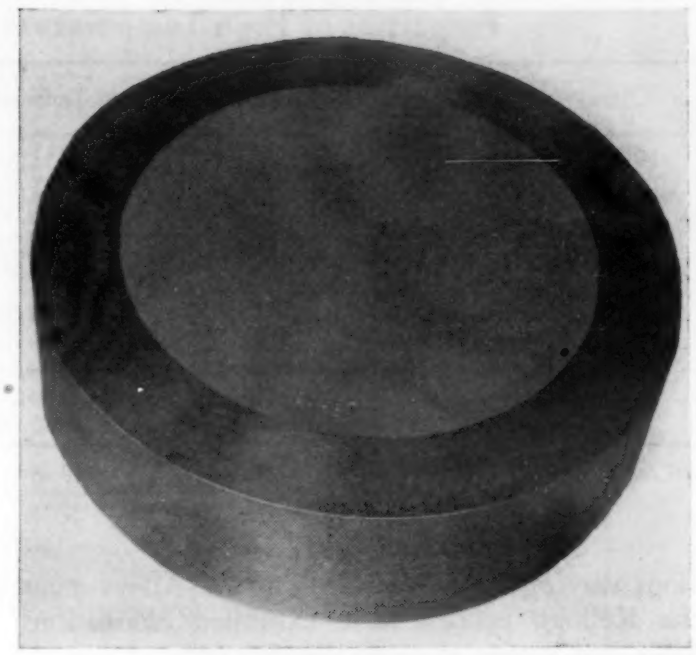
Alloys made by the electric ingot process are of exceptionally high quality. Since all the raw materials are melted simultaneously right in the ingot mold, high uniformity of chemical composition throughout the ingot is attained. Segregation, shrinkage cavities and pipes, which are always present in the center and upper portions of ingots made by conventional practice, are virtually eliminated. There are several reasons for this: (1) Solidification of the molten metal takes place rapidly because the mold is water-cooled. (2) The ingot solidifies by what might be termed "progressive solidification." Instead of the entire ingot being cast at once, only a relatively small volume of molten metal is present and solidifying at any one time. Thus, transfer of heat away from the liquid metal is much faster. (3) Liquid metal is fed continuously to the solidifying metal to compensate for shrinkage upon cooling. This feeding of molten metal continues to the very top of the ingot, so that the usual hot top is eliminated.

To illustrate the virtual elimination of segregation, a chemical analysis was made of a typical ingot of medium carbon, 12% chromium steel made by the electric ingot process. Samples were taken at top and bottom, outside and center. The chemical analysis at these various points is given below.

	Top Center	Top Outside	Bottom Center	Bottom Outside
C	0.35	0.37	0.35	0.36
Mn	0.53	0.54	0.54	0.55
Si	0.36	0.36	0.35	0.36
Cr	12.5	12.7	12.8	12.9

As a direct result of this high quality in the ingot metal, substantial improvement may be expected in its mechanical properties and processing characteristics.

As far as the process itself is concerned, practically all kinds of carbon and alloy steels can be produced. However, it is really a specialized process and for economic reasons is most applicable to the production of high quality, high cost alloys. It naturally cannot compete with the standard steel making practices for making ordinary SAE steels. There are, however, occasional applications where an exceptionally high quality, low alloy steel is required and electric ingot steel can be used to advantage. For example, regular SAE 4340 grade steel for certain airplane applications has been made by this process, and it is indicated that the relatively higher cost is justified.

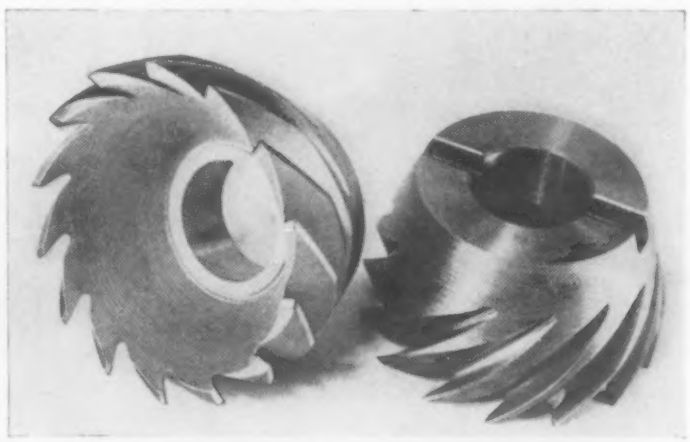


Composite ingots can be made by the electric ingot process. Shown here is one for a composite turbine wheel with a core of 4330 alloy and a rim of 19-9 DL alloy.

For the present, the process will be used chiefly for making high-speed tool steel, special types of stainless steel, and high temperature alloys. Work has also been done on other alloys including SAE 52100, special electrical steels, such as the high silicons and high aluminum metals, airplane exhaust valve steels, and special weldrod steels.

High Temperature Alloys

In the field of high temperature alloys, improvement in mechanical properties of materials made by this process is of special significance. The most striking advance is in ductility. High temperature alloys are notoriously lacking in ductility, particularly when the specimens are taken from the central portion of forged turbine rotors. They generally have elonga-



Milling cutters of DBL type high-speed tool steel formed directly from the cast ingot.

Properties of High Temperature Alloys Made by Electric Ingot Process

Steel	Bar No.	Tensile Psi.	Yield, Psi. 0.20% Offset	% Elong.	% R. A.
19-9 DL	1C	151,500	128,500	19.0	18.8
	2C	151,500	127,500	22.5	34.1
	3C	144,000	119,000	23.5	35.7
	1E	139,500	118,000	16.0	37.5
	2E	142,500	120,000	22.0	37.5
16 Cr-25 Ni-6 Mo	1C	120,500	93,000	28.0	36.3
	2C	130,000	103,500	28.0	45.2
	3C	120,500	93,000	26.5	37.3
	1E	123,250	93,750	23.5	41.3
	2E	125,500	97,500	22.0	43.7

All tests at room temperature. Bars marked "C" taken from center of forging; those marked "E" taken from rim.

tions varying from 0 to 10 to 15%. Alloys made by the Kellogg process have exhibited elongations of 20% and higher at room temperatures.

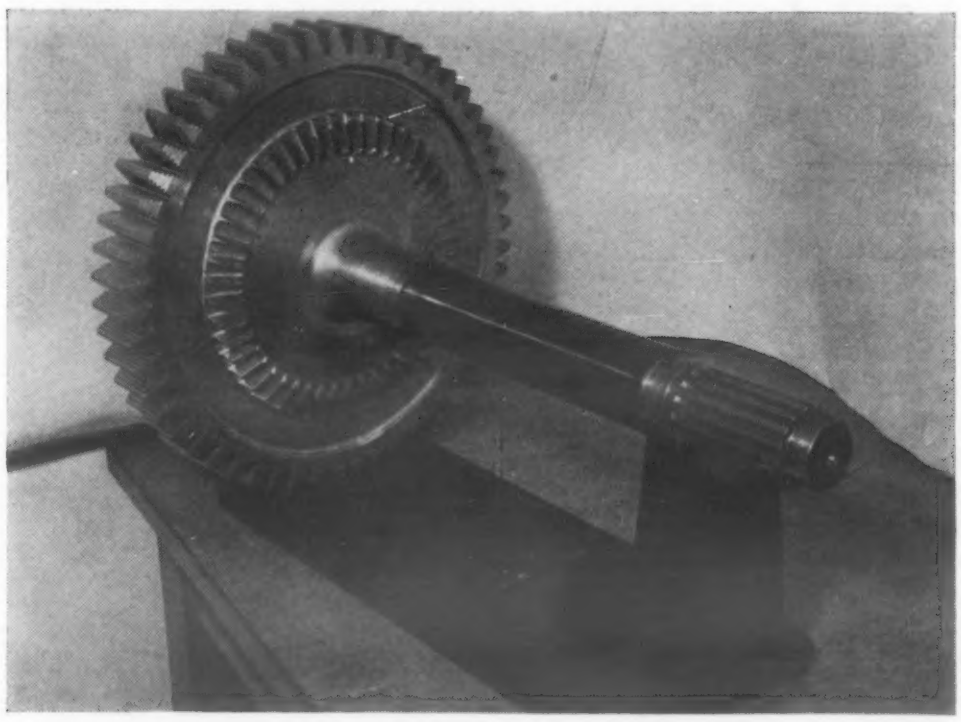
The accompanying table lists room temperature test results on samples taken from gas turbine rotor forgings made from electric ingot steels. The materials tested were: (1) 16-25-6 type, Timken Roller Bearing (16 chromium, 25 nickel, 6% molybdenum); (2) 19-9DL type, Universal Cyclops (19 chromium, 9% nickel). The bars marked "C" represent the central portion of the wheel, while the bars marked "E" represent the rim portion.

As yet only a few high temperature test results are available on electric ingot alloys. Several bars were taken from the central portion of a turbine rotor forging of 16-25-6 type alloy. These bars showed a stress to rupture life at 45,000 psi. at 1200 F of 145 hr.

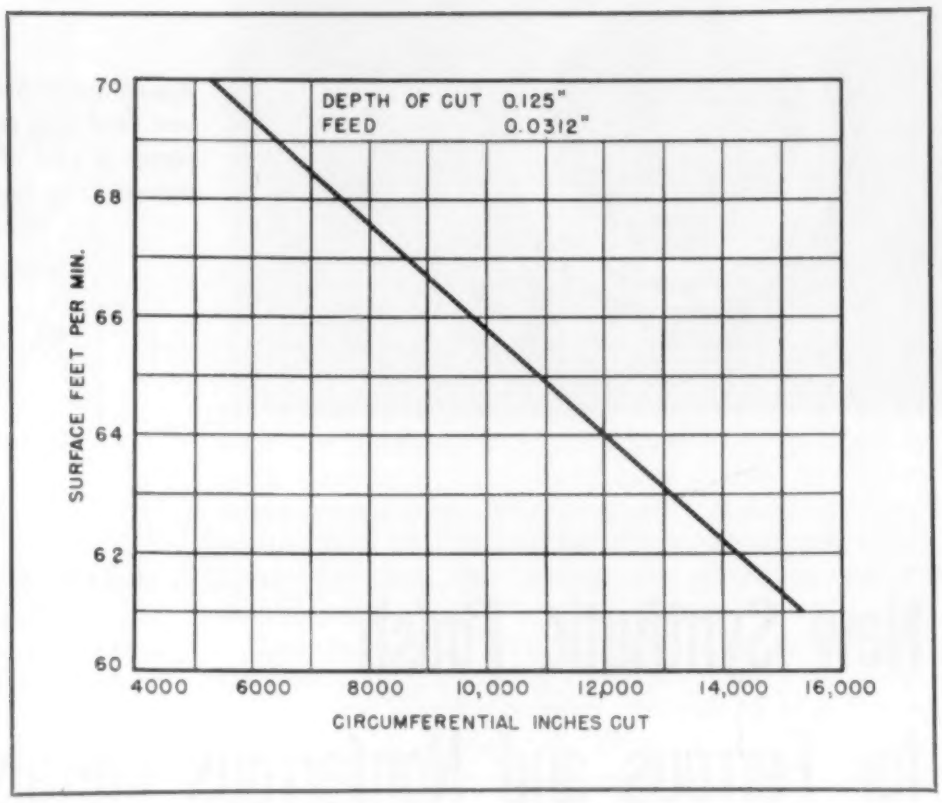
The processing characteristics of high temperature alloys made by this process are in most respects the same as those made by conventional melting practice. However, in forging them certain precautions must be taken to obtain their optimum properties. If normal forging procedures are used, forged billets from ingots made by conventional practice have better forgeability characteristics. The grain size in electric ingot alloys as-cast is, of course, larger than it is in billets that have already had some work done on them. For this reason special precautions are necessary during the early stages of forging. Care must be taken not to make too much of a reduction per heat and per blow of the hammer until the grains are initially broken down. After the grains have been worked out, normal procedure can be used. If this forging procedure is used, a higher uniformity will be obtained throughout the part as compared to parts from conventional billets which may vary considerably in uniformity and therefore in properties.

Up until now, in commercial practice high temperature alloys made by the electric ingot method have operated up to 1200 F and in experimental work, up to 1450 F. Work is now in progress on developing new alloys, using this process, for temperatures of 1500 F and higher.

At present gas turbine buckets are either precision cast or forged and then fastened to the rotor mechani-



An I-40 turbine wheel and shaft assembly before blading. Turbine wheel forged from electric ingot of 16-25-6 high temperature alloy.



Tool tests on chromium bearing steel with cutting tool of regular DBL high-speed steel made by electric ingot process.

cally or by welding. Often the rotor and buckets are made of different materials. A possible future application of the electric ingot process will be to produce a composite ingot, the core of which will be of the rotor alloy, while the outer layer will be of the bucket alloy. The buckets could then be machined out of the rim material. This would eliminate the joining operation and also possibly eliminate the area of weakness now present at the joint.

This ability of producing composite ingots made up of two different alloys should open up many other fields of application where materials with different properties are desired in the same part.

Tool Steels

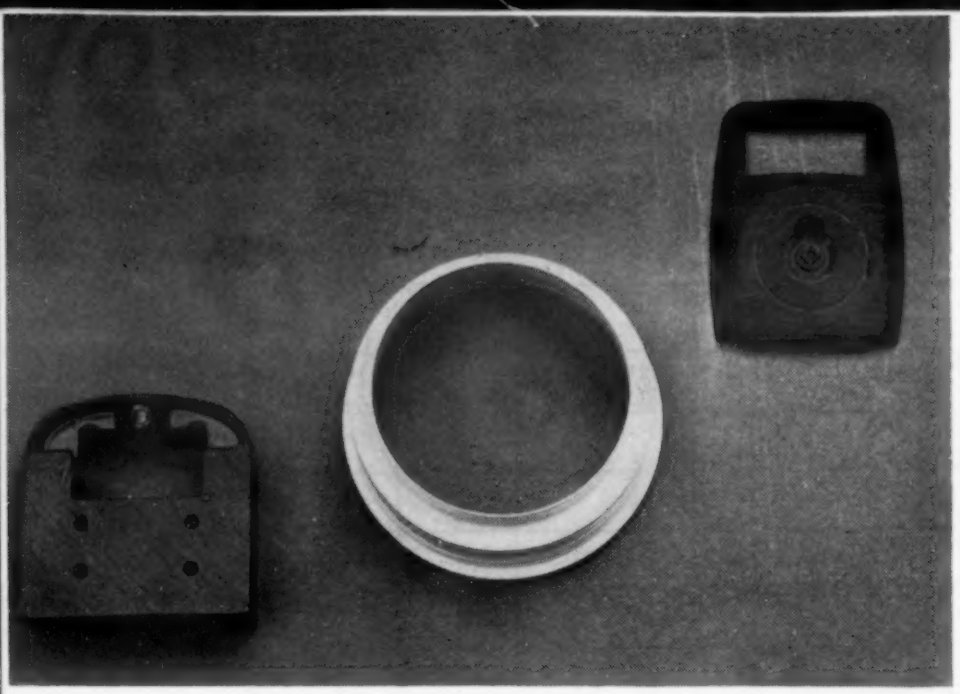
One of the first uses to which the electric ingot process was put was for making high-speed tool steels. In tool and die steels an important consideration is the carbide segregation usually present at the center of the ingot and in the subsequent bar stock. This segregation results in a brittle center zone with low ductility and impact properties. As mentioned previously, segregation is largely eliminated in electric ingot alloys. The brittle carbides instead of being concentrated at the center are uniformly dispersed throughout the alloy, resulting in higher and more uniform properties. On the accompanying chart the results of tool tests using regular DBL (chromium-tungsten-molybdenum) high-speed tool steel made by the electric ingot method are plotted.

An advantage of the process is that, where practical, tools and dies can be made directly from the cast ingot. An example of this is in the manufacture of milling cutters. The cutters vary in diameter from approximately 4 to 10 in., and the ingots are made to this size. They are then shaped from the ingot in the same fashion as are cutters made from forged high-speed steel bars. An extended series of tests indicated that cutters made from Kellogg ingots in no case showed a service life less than that of cutters made from forged rounds and, in some cases, showed a service life as much as 30% greater. And, in the past, milling cutters made from electric ingot alloys have sold for the same price as those made from forged bars. During the war they were applied in many industries for milling both ferrous and nonferrous materials.

Stainless Steels

All types of stainless steel can be made by the electric ingot process, but it probably will concentrate on applications where extra high quality is required or where special properties are needed. It has been found, for example, that the machinability of type 304 can be improved considerably by adding small amounts of lead which is uniformly dispersed through the alloy. Type 304 ordinarily is very tough and work hardens rapidly. Results of the Huey test for determining chemical corrosion and the Straus test for measuring intergranular corrosion have indicated that the corrosion resistance of lead-modified type 304 is as good as the regular type 304 and better than free machining type 303. In addition, the weldability of these materials is improved.

In summary then, the electric ingot process offers a new and unique method of producing alloys of extra high quality and uniformity. The most important applications of these alloys have been discussed and should give some idea of their present range of use. But the process is still new; there certainly will be further improvements and refinements which will probably result in more economical production, and thus make possible an even wider application of electric ingot ferrous and nonferrous alloys.



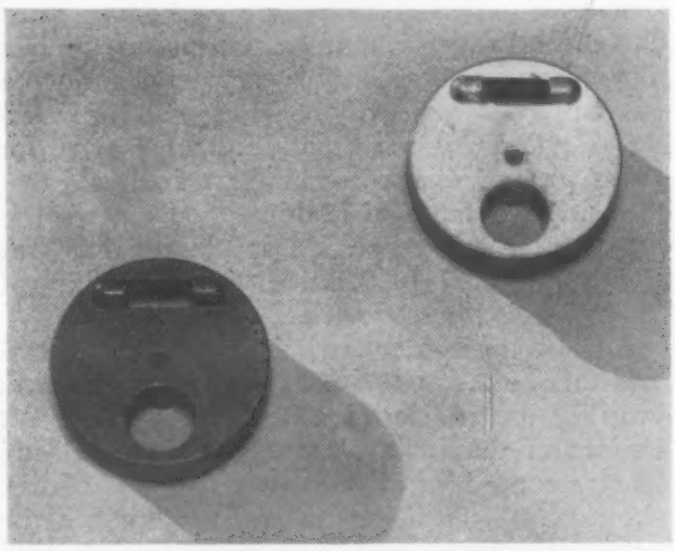
Typical parts finished with the new vinyl type coatings. In the center is part of an aluminum thermos jug liner finished in white.

New Synthetic Finish for Ferrous and Nonferrous Metals

by **CARL L. SHAPIRO,** President, Acryvin Corp. of America

IN ORGANIC FINISHING of most metals—particularly nonferrous metals such as zinc, aluminum, magnesium and copper—chemical pretreatment of the surface is almost always required to achieve good adhesion of the coating to the metal surface. Also, in many cases special primer coats are necessary. A new line of synthetic finishes, with the trade name "Acraclad," has been developed that eliminates these chemical pretreatments and primer coats. The new coatings also feature quick drying, ranging from 2 to 20 min. at temperatures of 250 to 350 F, as well as good hiding power, and high surface coverage.

These new coatings have been in development for almost six years. The Acryvin Corp. of America has submitted them to extensive tests in their own laboratories, and they are now being tested in the field by a number of metal parts fabricators.



The finishes are applicable to zinc die castings without previous chemical pretreatment. Here shown is a small casting before (top) and after (bottom) being coated.

Nature of the Coatings

The finishes are essentially a vinyl type coating. Through special formulation and processing, stabilization of ingredients is achieved so that there is very little separation of pigment from vehicle. This makes possible a marked increase in the body or solids content of the coatings. Usually the solids content of vinyl coatings runs up to around 25 or 30%; in these stabilized coatings, solid contents up to 40% can be formulated. Another important characteristic is that no plasticizers are required to give the coatings the necessary flexibility and adhesion.

All types of pigments can be used in the formulations, including standard organic pigments and metallic powders such as bronze and aluminum. The coatings can also be used unpigmented where a clear finish is desired.

Acraclad finishes are applicable to all ferrous and nonferrous materials. From the standpoint of adhesion and compatibility with the metal being coated, there are two main types or formulations. One formulation is applicable to irons and steels, and the other to nonferrous materials. The nonferrous formulation can be used on all the common nonferrous metals and

Chemical pretreatments and primer coats can be eliminated in finishing metals with a new vinyl type coating which dries in from 2 to 20 min. at 300 F.

alloys including zinc, aluminum, magnesium and copper. This same formulation, if desired, can also be used on ferrous metals with good results. These two general types can, of course, be varied widely in their formulation to meet specific requirements of a job.

The coatings are odorless, tasteless and non-toxic. They are available in all standard colors, and also in water-clear and transparent shades. They vary from flat and satin finishes to high glosses. Their color retention is good up to 250 F, and the whites are non-yellowing up to this temperature.

The opaque coatings, including the whites, have exceptionally high hiding power. This is largely due to their relatively high solids content. Another result of the high solids content is their high surface area coverage or "mileage" characteristics: average coverage is 350 to 450 sq. ft. per gal.

The coatings are equally suited for single or multiple coat paint systems. Where not much build-up is required or where only mild service conditions are encountered, a single coat application has proved satisfactory. Where service conditions are more severe, a number of coats may be used. The film thickness of a single layer ranges from a minimum of 0.00005 in. to a maximum of 0.0035 in. The minimum thickness films are obtained by roller coat application. Good hiding power is obtained even with the very thin films.

The thin coatings have some lubricating characteristics and can be used to advantage for coating assemblies having bearing parts that are subjected to low friction service conditions. One typical application is coating meat grinder bearings. Another is coating of casters for hand trucks. In this particular application instead of coating the individual parts separately, they are coated when finally assembled, with the bearings in place. The thickness of coating runs about 0.001 in. and completely covers all the interior bearings as well as the exterior of the casters.

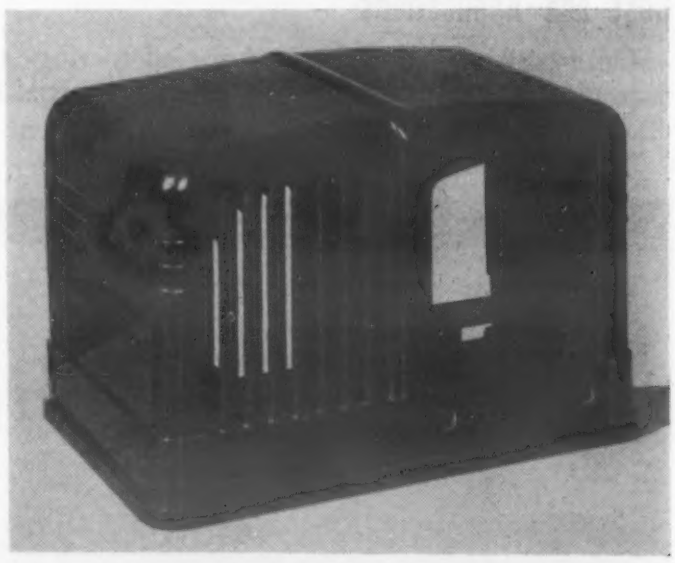
Characteristics and Properties

Perhaps the most outstanding property of these new coatings is their ability to adhere strongly to metals that are normally difficult to coat with organic finishes. And, as has been mentioned previously, this excellent adhesion is achieved without chemical or mechanical pretreatment of the metal surface to be coated. Normally in coating zinc die castings, for example, a chemical pretreatment such as phosphating is mandatory to insure good adhesion of the finish. A primer coat, usually of the zinc chromate type, is also required for successful adhesion of subsequent coats.

With the new vinyl type coatings these two steps are eliminated. The metal pretreating action is formulated right into the coating itself. When applied, certain of the coating ingredients provide chemical pretreatment and a passivating action to the metal, which results in good affinity of the coating material with the metal surface. However, as with other organic coatings, a carefully cleaned surface is required to get proper adhesion. Grease, dirt, and other foreign matter must be removed by regular degreasing operations. On zinc die castings, for example, alkaline degreasing has given very satisfactory results.

The durability characteristics—wear and abrasion resistance, toughness and flexibility, chip resistance—are in most respects similar to those of the conventional vinyl type coatings. They are tough and flexible; they have high film strength, good chip resistance and high resistance to wear and abrasion. For example, an abrasion test on one of the coatings with a Taber abraser showed a loss of less than 70 mg. per 1000 cycles under a 100 gm. load. Good results were also obtained in crush tests of these coatings. The crush test consists of putting a coated tube over a mandrel and squeezing it together along the length of the mandrel. The tube in this condition is heated to 140 F and held for two weeks, after which it is expanded to its original shape. Acraclad coatings applied to tubes by dip, spray or flush coat and submitted to this test showed no failures in the coating. The coatings have also been applied to metals in the flat and subsequently drawn or formed into final form without failure of the finish.

In heat and cold resistance characteristics they are also similar to other vinyls. They are stable up to around 250 F. However, the black coatings and those pigmented with metallic powders can be used in special applications up to 300 F. As for cold resis-



A phenolic resin radio cabinet finished with an Acraclad coating.

tance, they retain their flexibility at temperatures as low as −60 F.

The corrosion resistance of Acraclad coatings also runs similar to that of other vinyl type coatings. They exhibit excellent resistance to moisture, salt spray, weak acids and strong alkalies. In salt spray tests they have satisfactorily withstood 20% salt solutions at 100 F for 750 hr. In 100% humidity tests, no failures in the coatings were observed after 1000 hr. at 100 F. The coatings also have proved stable in sunlight and accelerated weathering tests. Because of the passivating action of the coating ingredients, it was found that when breaks occur in the coating, corrosion is limited to the break-through area.

Satisfactory results were also obtained on stain tests in which the coatings were exposed to the staining medium for 24 hr. at 100 F. A few of the substances used in these stain tests were tomato and lemon juice, butter, bacon grease, mustard, mayonnaise and blood.

Acraclad coatings can be applied by all the conventional methods, including brushing, dipping, spraying, flushing or flow coating, and roller coating. In application and drying, they behave much like conventional lacquers. They dry principally by evaporation of volatile solvents, but in addition require the application of heat to complete the curing cycle and insure good fusion of the coating to the metal surface. Both convection and infra-red ovens can be used for this purpose. The various formulations of Acraclad coatings provide a wide range of baking cycles. The time varies from 2 min. up to 30 min. in exceptional cases, and the temperature varies from 200 to 400 F. Thin roller coat applications require only 2 to 5 min. at 350 F; die castings and most other metal forms run between 10 and 20 min. at 250 to 300 F.

There is practically no time lag required for setting-up of the wet film after application and before being put into the oven to dry. After baking, no aging is required to achieve optimum properties. Because the coating has good high temperature shock resistance, coated parts can be handled immediately after being removed from the oven for assembly operations or for packaging.

Cost and Applications

On a cost per gallon basis, Acraclad coatings compare closely with many of the regular industrial baking enamels and lacquers. But in figuring the true cost, coverage per gallon must also be considered. As has been indicated previously, increased solids content in these vinyl coatings has made possible a significant increase in coverage as compared to conventional vinyl types; and this factor results in a lower actual cost per square foot of coverage. Other cost factors that must be considered are elimination of chemical pretreatments when these coatings are used, and in many applications the decrease of processing time in the oven.

Some of the applications of Acraclad vinyl coatings have already been indicated. Perhaps one of its most promising fields of application is for die castings. Automobile parts such as carburetors, and fuel and oil pumps can be finished directly without previous chemical treatments. The coatings are ideal for photographic equipment, such as exposure meters and camera cases, and for optical and scientific instruments. Food containers, container tops, and household appliances are a few of the other possible applications.

A typical application in which these coatings are presently being used is for coating thermos jug liners made of aluminum. Previously the liners were left uncoated, because the coatings tried had poor adhesion and corrosion resistance; rejections ran up to as high as 20%. Using an Acraclad type finish, the adhesion and corrosion problems were solved and the rejects were cut to almost nothing.

Another use is for coating fishing poles. Formerly the poles, which are made of steel, were given pretreatment in a phosphating solution. However, the solution could not be thoroughly washed out of the joints, and the joints had a tendency to corrode while in service due to the reaction of the remaining chemicals. This trouble is eliminated when using the new vinyl coatings because chemical pretreatment is not required.

Besides being a finish for metals, these coatings have also been used successfully on molded phenolic plastics. One of the important applications has been coating radio cabinets made of phenolic resins.

The above are just a few of the many possible applications of the Acraclad vinyl coatings. Because of their advantages and special characteristics discussed in this article, the coatings should find many additional applications in the future.

A one-coat application of the new vinyl coating to a stamped aluminum refrigerator panel.

Ceramics are being developed for use both as solid shapes and as coatings for metals which will serve at operating temperatures well above 1500 F.

Ceramic Materials Show Promise for High Temperature Mechanical Parts

by JOSEPH R. BRESSMAN, Research Engineer, DeLaval Steam Turbine Co.

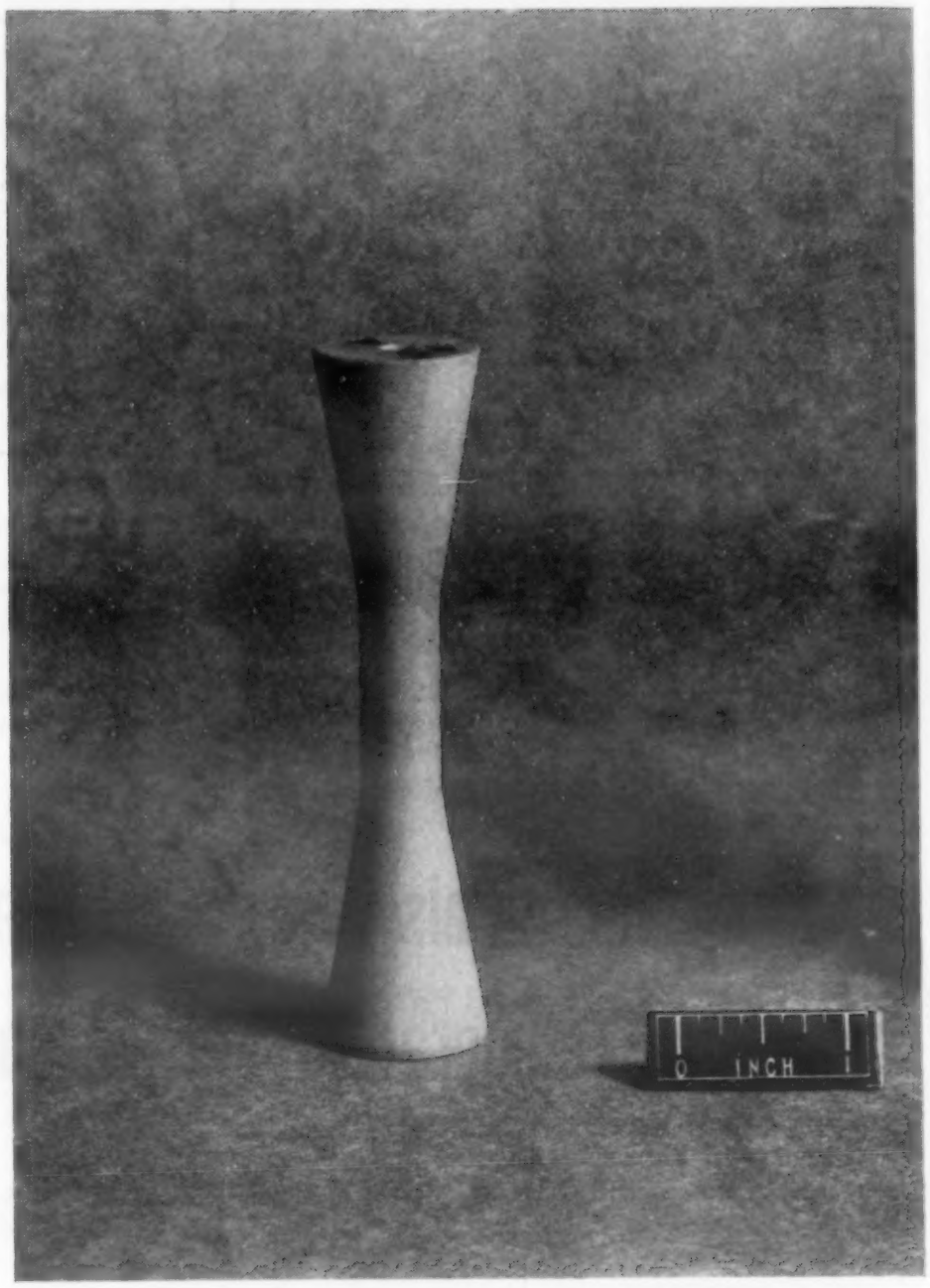
ONE OF THE IMPORTANT material advances of recent years has been the development of high strength ceramic materials for high temperature service. The coming of the jet engine, gas turbine, rocket, and the atomic energy plant with their demands for new and better high temperature materials stimulated this development. This was to be expected since ceramics possess a number of inherent advantages over metals. Their melting points are, in general, much higher. Their bulk density, a property of great value in rotating disks and blades, is considerably lower. And they are very hard and chemically inert, therefore more resistant to erosion and corrosion and longer lived.

The development work on high strength refractories before World War II was rather limited. The best materials in use industrially were the mullite and high aluminum oxide bodies. These were used for spark plugs, furnace bricks, glass melting tanks, and pyrometer tubes.

During the war the immediate problems of the jet engine and the rocket stimulated active research in ceramic materials both here and abroad. The basic object of German research was, however, somewhat different from that in this country. The German need was for "ersatz" materials that would replace the high alloy nickel, chromium, steels for operation at temperatures of 1300 to 1500 F in machines that could be used immediately in their war effort.

Early German efforts at manufacturing a ceramic turbine were marked by what would appear to be a poor judgment of ceramic material properties. After 1944, however, research on more promising materials such as aluminum oxide, sillimanite, and beryllia was conducted. Perhaps the most promising development was the investigation of materials that were combinations of metals and ceramics manufactured by molding and firing mixtures of the powdered products. A material known as "Dug," which was a combination of iron and aluminum oxide, was thought to have great potentialities by German engineers.

The main purpose of American research has not been to substitute ceramics for metals in the range 1300 to 1500 F, but to develop ceramics that will permit operations at temperatures above 1500 F. The investigations have proceeded along two chief lines: (1) the development of solid ceramic shapes for high temperature parts; and (2) the development of ceramic coatings to protect metals from corrosion at high temperatures.



In these two illustrations are shown ceramic test specimens. At left is a test piece as manufactured, and at right a similar piece is ready for tests with gaskets on its ends.

Requirements for High Temperature Service

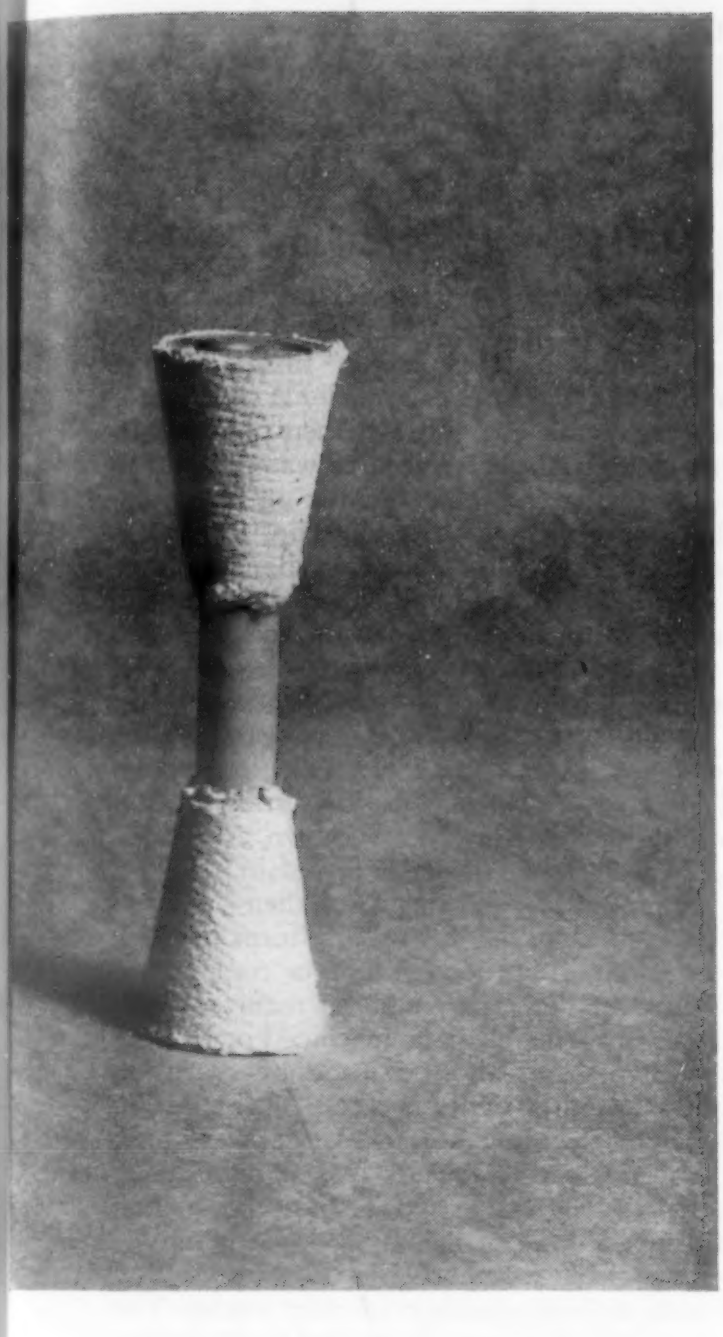
The requirements of materials of construction for the gas turbine and jet engine are very severe. The first requirement of a ceramic is that it have sufficient strength to support tremendous centrifugal loads. In this respect ceramics have an inherent advantage over metals. The centrifugal force in a rotating blade is proportional to the density of the material; the higher the density the greater the tensile strength must be. The density of high temperature ceramics varies from 2.5 to 5, as compared to 7 or 8 for high temperature alloys.

Closely related to this strength requirement are the stress-rupture and creep strength properties. For aircraft use, which involves a relatively short operational life, the stress-rupture strength is used as a design criterion. For example, the material may be designed for 500- to 1000-hr. life for transport service, 150 hr. for military pursuit planes, or even 1 to 4 hr. for a guided missile engine.

The creep strength is used as a design criterion for such purposes as marine, locomotive and stationary power plants. The load to cause 0.1% elongation in 10,000 or 100,000 hr. is often used.

Gas turbines, superchargers and jet engines rotate so rapidly that the materials pass through millions of stress cycles in a very short time; consequently, the fatigue strength is of importance for any application except, perhaps, guided-missile application.

In addition to the extraordinary demands on stress-rupture, creep and fatigue strength, the material must be resistant to mechanical and thermal shock to an unusual degree. The blades of a turbine are subjected to considerable handling on installation and engine assembly. Pieces of the combustion chamber and nozzles have been known to break off and strike the rotating blades. The operating clearances between the blade tips and the casings are made as small as possible in the interests of high efficiency, and very often rubbing at high speeds may occur. When an engine is started up, the temperature of the gases



striking the blades may rise 1500 F in 10 to 15 sec. Should the fuel suddenly be shut off or the combustion chamber flames blow out at altitude, cool air would immediately strike the red hot blades.

Other requirements of ceramics for gas turbines are similar to those for metals. The ceramics should have good resistance to corrosion and erosion. A high value of damping coefficient, which would reduce blade vibration, is desirable. Finally, a low value of thermal conductivity may be advantageous where ceramic blades are fixed in a metal disk, in which case less heat would be conducted to the disk.

The Materials and Their Properties

The most important high temperature ceramics at present are compositions that contain combinations of refractory oxides of the following elements: beryllium (BeO), aluminum (Al_2O_3), zirconium (ZrO_2), thorium (ThO_2), magnesium (MgO), and calcium (CaO). Typical bodies developed by the Bureau of Standards contain large percentages of beryllium oxide or zirconium oxide with smaller quantities of the oxides of magnesium, calcium, silicon, titanium or boron. Older refractory bodies contained large proportions of mullite ($3Al_2O_3$ $2SiO_2$).

These refractory oxides are generally found in natural ores, such as silicates of aluminum (sillimanite, kyonite and andalusite), and require varying degrees of concentration and refining. They are all available in the Western Hemisphere.

The available information on high temperature properties of ceramic materials is still very limited. One of the difficulties in securing accurate tensile test results with brittle materials such as ceramics is the necessity for eliminating or minimizing bending stresses caused by misalignment of the apparatus. This requires the accurate machining of all the tensile loading equipment, a grip that will not result in failures in the clamped portion of the test specimen and a simple means of checking the alignment. For a ½-in. dia. specimen, a misalignment of the apparatus of 0.005 in. will result in a bending stress that is approximately 10% of the average stress.

Short-time tensile and stress-rupture tests were conducted at the National Advisory Committee for Aeronautics (NACA) on specimens prepared from a sillimanite ore by the hydropress method. The specimens were fired at 3100 F, and consisted largely of mullite and free silica in the form of cristobalite. The results of the short-time tensile tests are indicated in the chart. Note that the tensile strength at 1800 F was greater than the room temperature tensile strength.

Another interesting fact is the effect of heat treatment. When the specimens were heated for ½ hr. at 1800 F and cooled slowly, they exhibited higher tensile strengths up to 1400 F than the specimens that were not heat treated.

The results of stress-rupture tests are indicated in Table 1. The stress-rupture strength decreased rapidly from 1400 F to 1800 F. However, it must be remembered that this material had a density one-third that of high temperature steels, and the stresses indicated in the table should be multiplied by three before compared with steels. On this basis the mullite refractory had a greater stress-rupture strength for 1000 hr. at 1600 F than any gas turbine metal.

Table I—Stress-to-Rupture Tests on Sillimanite Refractory

Temperature (F)	Stress (Psi.)	Time to Rupture (Hr.)
1800	9400	0.42
	8500	1.17
	6700	19.1
1600	9600	99.2
	8600	722
1400	6750	522*
	7700	242*
	8650	212*
	9600	251

** Specimen did not fail under these stress conditions; at the end of this time the stress was increased to the next higher increment.*

Much more encouraging stress-rupture and creep results were achieved on new compositions devised and tested by the Bureau of Standards. The bodies tested were simple compositions of refractory oxides whose main constituents were BeO or ZrO_2. The specimens were also hydropressed in rubber molds.

The best results in creep tests were obtained on a composition known as body 4811, which consisted approximately of 84 BeO, 7 each of Al_2O_3 and ZrO_2, and 2% CaO. The bulk density of this body was 3.0, which is slightly higher than that of the sillimanite but still approximately one-third that of high temperature steels. The 4811 specimen was tested at 1800 F by increasing the stress from 9000 to 14,000 psi. at intervals of approximately one week. The total test time on the single specimen, including preliminary tests at various lower temperatures, was 2589 hr. The test was discontinued after 117 hr. at 14,000 psi. because the thermocouples became unreliable. The creep of this specimen was the lowest of all those tested at 1800 F. At 2100 F, however, the deformation was excessive. The results on this body may be summarized by noting that satisfactory resistance to creep and rupture were achieved at a stress of 14,000 psi. at 1500 F, 13,000 psi. at 1800 F, and 4000 psi. at 2050 F. The 4811 body is better than ordinary metals at 1800 F on a straight strength comparison, and is far superior when compared on a strength-density ratio basis.

Test results on a small ceramic-bladed turbine are described in a report of the NACA. The blades were made of the same sillimanite refractory on which tensile test results were reported. The turbine was run for a total time of about 38 hr. at speeds up to 8700 rpm. and at temperatures up to 1725 F. The blades were subjected to 30 starts and 36 temperature cycles. Although the results of these first turbine tests are inadequate from the standpoint of aircraft requirements, it is felt that they are sufficiently encouraging to warrant continued research and development.

As mentioned previously, the thermal shock requirements of a gas turbine are very great and as yet no standard test has been devised. It is apparent, however, that actual turbine conditions must be reproduced as accurately as possible on a specimen whose shape is similar to that of a blade, if a good prediction of a turbine's heat shock characteristics is to be made. The bureau of standards used a simple test method in rating various bodies to be used in tension tests. Test bars were quenched in a blast of cool air from a temperature of 1500 to 1700 F. After 15 min. in the air-blast the specimens were returned to the furnace. After ten cycles flexure tests were made and compared with room temperature results. Body 4811 suffered practically no change in modulus of rupture in undergoing this test.

Interesting results were achieved at the NACA on an apparatus that approached actual turbine operating conditions. A single ceramic blade was mounted in a simulated nozzle section in which a quartz window was installed. A high velocity gas stream was directed over the blade and the rate of heating and cooling could be varied. Sillimanite turbine blades successfully withstood heating cycles with a temperature rise from 400 to 1500 F at the rate of 24,000 F per min. Two out of the three blades broke on the cooling cycle at this same rate. The blades withstood repeated cooling cycles at a temperature change rate of 20,000 F per min.

Forming and Fabricating Ceramic Parts

The high temperature refractories can be formed into various shapes by many methods. Complicated shapes can be made by "slip casting." In this method a plaster mold of the object is made. A thin paste or slip of the ceramic and water is then poured into the hollow mold. The plaster absorbs water from the slip depositing a layer of the ceramic on the mold. When the proper thickness has built up, the excess is drained off. The object can then be dried, removed from the mold and fired. Slip castings usually result in objects of low bulk density and strength, and are subject to large shrinkages.

Objects of high strengths can be made by dry pressing in which practically dry ceramic powders are compacted under pressure in a mold. The piece is then removed and fired in a furnace. An interesting method of accomplishing this is a process known as "hydropressing," in which the powder is placed in a rubber mold of the proper size and shape and then subjected to hydrostatic pressure. In this way uniform pressure can be exerted on all portions of long or complicated shapes. When the "green" ceramic is removed from the mold it is firm enough to be machined or ground.

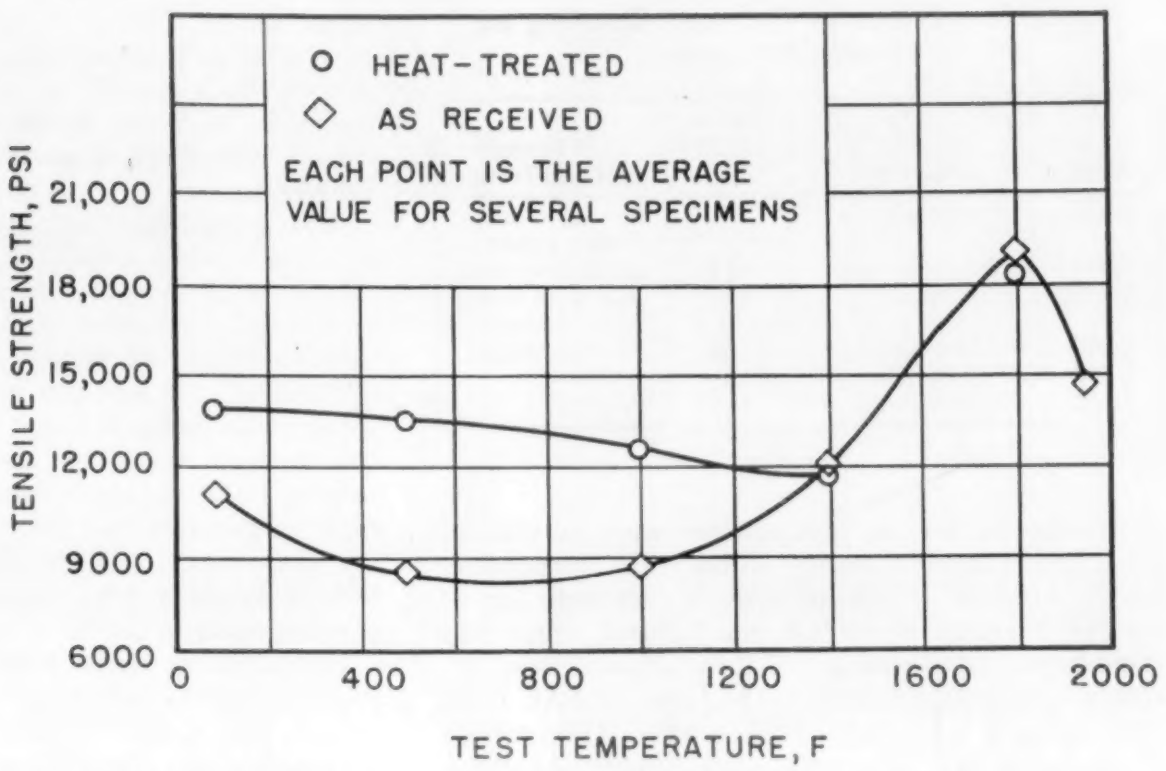
Ceramic shapes can also be made by extrusion through dies. Another useful method of fabrication is casting from the molten state. Large glass tank blocks are made in this way by melting mullite at temperatures over 3300 F and casting the molten liquid into special molds.

Where fine tolerances are necessary, the dry pressing methods such as hydropressing are very useful. The "green" or unfired object can be molded to the proper size, taking into account shrinkage in the furnace. Objects have been made in this way to tolerances of ± 0.002 in. Where closer tolerances are necessary, surfaces must be ground after firing.

One of the most difficult problems to overcome in the manufacture of ceramic turbine blades is the fabrication of the thin twisted airfoil shapes necessary for high efficiency. Another important problem to be overcome is that of fastening a ceramic blade to a metal disk. Inasmuch as the ceramic materials exhibit no plastic deformation at room temperature, it is impossible to press a ceramic blade root into a slot in the disk. In addition, from the results of recent tests it appears to be impractical to fabricate and utilize a complicated blade fastening with small fillets such as are necessary in the conventional "fir tree" type of root.

Refractory Coatings for Metals

Although porcelain enamel coatings had been used for years for many industrial and domestic purposes, such as kitchen and bathroom equipment, chemical process apparatus and automobile exhaust manifolds, it was not until World War II that extensive devel-



This graph shows how the tensile strength of sillimanite refractory varies with the temperature.

opments in the use of high temperature coatings were made.

Ceramic coatings for high temperature use require several special characteristics that are peculiar to their application. A coating must, of course, adhere well to the base metal over the full range of temperatures to which it will be submitted. This means that the rate of thermal expansion must be quite similar to that of the base metal. The coating should have high resistance to thermal shock and temperature gradients. A continuous sealed surface must be maintained over the metal in order to protect it from oxidation. Finally, the material should have a low solubility for metals or their oxides and should not "reboil." Reboil is the property that results in the appearance of gas bubbles in the coating and usually occurs on reheating after the first firing operation.

Ceramic coatings are formulated from a "frit" or glassy constituent, which acts as a binder, and the more refractory particles which increase the high temperature strength. The frits used are special glass compositions to which titania, silica, feldspar, alumina, zirconia, silicon carbide, mullite or fluorospar are added to increase the refractoriness of the frit. The thermal expansion of these frits is increased by substituting lead oxide for boric oxide and titania for silica. The refractory particles added to the frit are alumina, chromium oxide, cobalt oxide, manganese dioxide, nickel oxide, magnesium oxide, calcium silicate, calcium chromate, and calcium fluoride. Coatings made with alumina or combinations of alumina and chromic oxide showed promising characteristics from the standpoint of refractoriness, corrosion protection, and thermal shock.

The refractory ceramic coatings are prepared in a manner similar to that for ordinary porcelain enamels. The base metal must be properly cleaned and free of grease. It must be pickled or, if possible, sandblasted and given a nickel flash. The coatings are usually sprayed on but can be applied to interior surfaces by dipping. The coatings are then dried and fired. Single coatings are of the order of 0.002 to 0.004 in. thick. Thicker coatings can be applied but will suffer from reduced thermal shock resistance and a greater tendency to chipping due to thermal expansion. The firing temperature with ordinary steels is 1500 to 1600 F.

Flame impingement and themal shock tests by air blasts, water sprays and water immersion on several commercial and special refractory coatings have been reported by the Bureau of Standards. Probably the most severe heat shock test was the water immersion test. Flat specimens of low carbon steel coated with various enamels were heated in a furnace to 600 F and then submerged in water. If the specimen was not damaged the furnace temperature was raised 100 F and the immersion repeated. All the commercial enamels failed at temperatures of 1100 F or lower. A thin high alumina coating did not fail at 1600 F. Another coating twice as thick failed at 1200 F. These tests indicated the value of a thin coating in severe heat shock.

The ability of the coatings to protect the base metal against corrosion was determined by placing

Table II—Effect of Ceramic Coating on Tensile Strength

Alloy	Coating	Time at 1350 F (Hr.)	Yield Strength at Room Temp.
S-816	None	471	Specimen broke before testing
S-816	Alumina type	471	69,000 average
S-590	None	189	Specimen broke before testing
S-590	Alumina type	189	70,000 average
S-590	None	101	33,000
S-590	Cobalt oxide type	101	76,000

specimens in various atmospheres with or without load. The effect of a coating on the room temperature tensile strength of low alloy steels that were heated for 500 hr. in air at 1200 F is as follows: ingot iron, coated specimen strength, 225% greater than uncoated specimen; SAE 1010, 55% greater; SAE 1020, 25% greater; SAE 4130, 16% greater. The coatings on the last two specimens were slightly blistered, which reduced their effectiveness. Similar tests were conducted on high temperature alloys at 1350 F in an atmosphere of hydrogen sulfide, which was found to be particularly corrosive. The results of these tests are indicated in Table 2.

Although some stress-rupture tests were conducted at 1350 F in steam, oxygen and air, no definite conclusions can be drawn because of the limited data. In some cases the coating increased the strength while in others the reduction was reported. However, because of the inexactness of a stress-rupture determination, a large number of tests must be averaged before a definite trend can be ascertained.

Service tests have also been conducted on aircraft and tank exhaust manifolds and collector rings, turbosupercharger blades, jet engine and buzz bomb flame tubes. The coatings proved so successful for exhausting systems that they were used in regular production for many Army and Navy applications. The ceramic coatings of the jet engine flame tubes doubled the life of the tubes in service tests. Buzz bomb flame tubes ran cooler and were not subject to heat warping.

The new refractory coatings, although showing great promise and potentialities, have some limitations. The temperatures at which the coatings can be used have a potential limit in that the firing temperatures must increase with increased refractoriness but obviously cannot exceed the melting point of the base metal.

The coatings are also brittle and subject to mechanical failures such as chipping and fracturing. Under high centrifugal forces such as exist in turbine blades, the viscous coatings may flow toward the blade tips and thin out at the blade roots, leaving the latter, which are more highly stressed, unprotected; or, if the coating is rigid enough not to flow under the influence of the high centrifugal stress, it may chip as a result of the severe vibration which the blades undergo.

Any pores in the coating that pass unnoticed during inspection or develop in operation will result in the base surface becoming unprotected. Finally, coatings that are thick enough to insulate the base metal and reduce its operating temperature but still give satisfactory heat shock characteristics have not been developed to date.

The applications and fields of use of high temperature ceramic coating have been barely touched. As a result of the war-time research they have already entrenched themselves for many military uses. For aircraft engines of various types, piston, jet and gas turbine, the coatings can be used for exhaust manifolds, stacks, collector rings, turbosupercharger blades, combustion chambers, after-burners and exhaust nozzles. Industrial applications might be furnace parts, high temperature heat exchangers, chemical processing apparatus, smoke stacks, hot gas ducts, steam turbine blades, nozzles, piping and other steam power plant equipment.

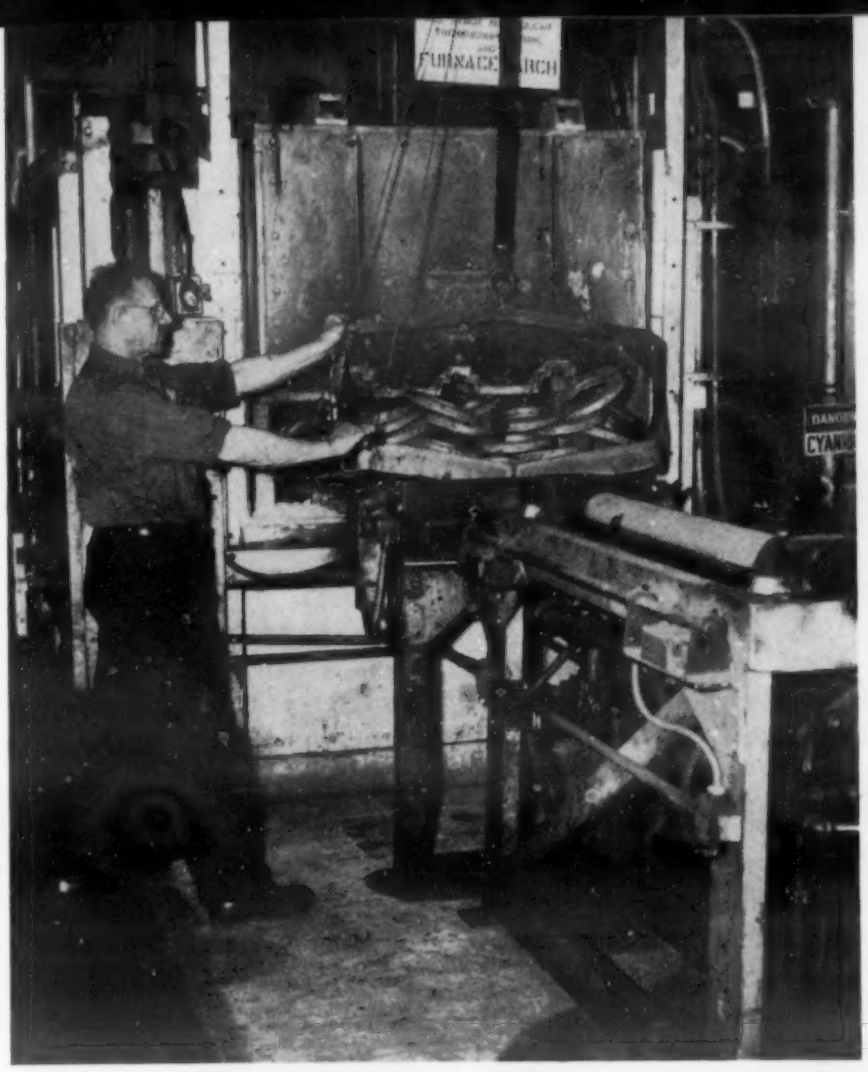
Although the initial research efforts on high temperature ceramic coatings were successful, it is expected that continued work will result in higher permissible operating temperatures, greater resistance to thermal shock, and chipping. In addition, the development of ceramic coatings for such materials as silicon carbide and the ceramic-metal combinations may bring about materials for application in a new and higher temperature range.

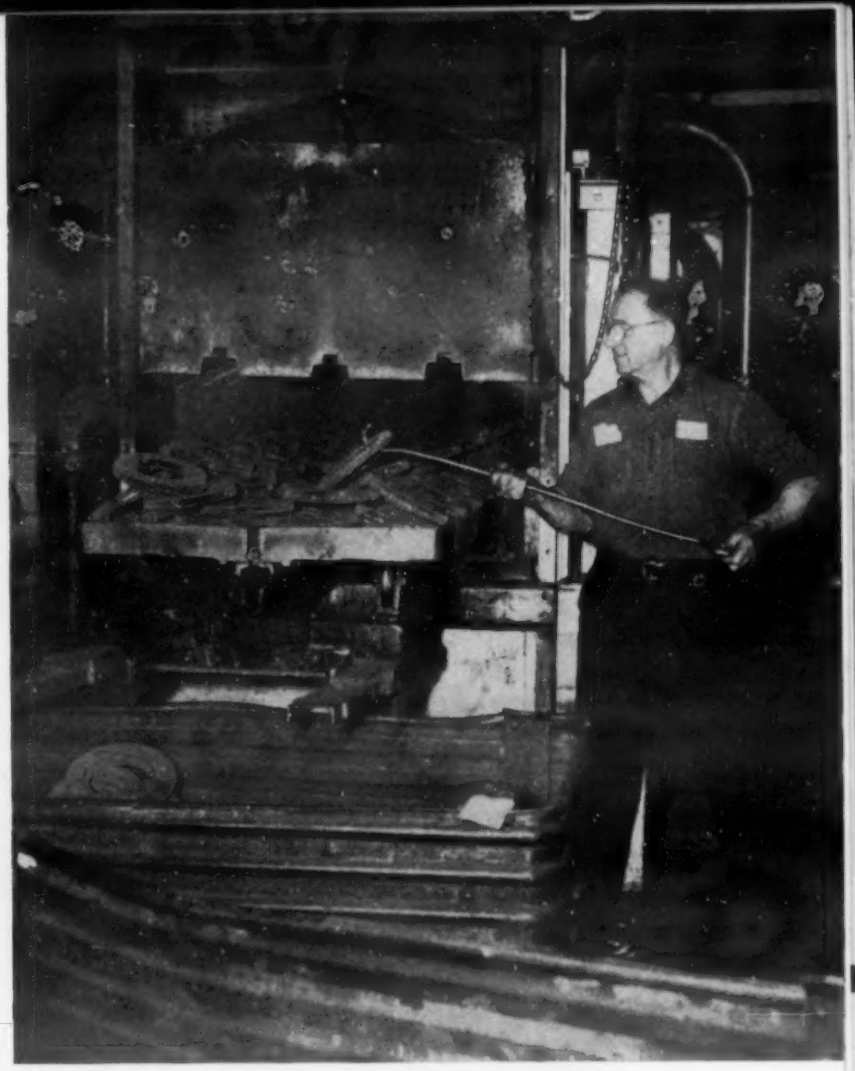
Mixtures of Ceramic Materials and Metals

At the close of the war the Germans were experimenting with mixtures of ceramics and metals in an attempt to increase thermal and mechanical shock resistance. This is the same principle as used in the manufacture of Carboloy tools. The ceramic and metal powders are mixed together, pressed in a mold, and fired. By this means a great range of mixtures with controlled physical properties can be achieved. In addition to increased thermal and mechanical shock resistance, fabrication and structural design of blade shapes and roots can be simplified.

The mixtures have an inherent disadvantage in that the density is usually higher and the corrosion resistance somewhat lower than the pure ceramic material. The Brown-Boveri Co. has a patent on a metal and ceramic turbine blade that is ceramic at the tip and contains increasing quantities of metal toward the root. Because of the great number of substances that can be utilized—carbides, borides and oxides, metals such as molybdenum, tungsten, and cobalt—this type of material appears to have great promise for many applications.

The study of ceramic materials has just started. There are many facts concerning basic material properties that must still be determined. Future developments will follow along the lines of developing new materials with greater heat shock resistance and strength at temperatures in excess of 2000 F, and developing new manufacturing techniques and methods for mechanically joining ceramics and metals or ceramics and ceramics. With developments such as these, the use of high temperature ceramic materials will continue to expand in the future.





(1) Forged pieces move through a four-zone furnace at Cadillac Div. of General Motors. (A) A pusher mechanism, hydraulically operated, loads the furnace automatically. (B) Annealed pieces are removed at the discharge end.

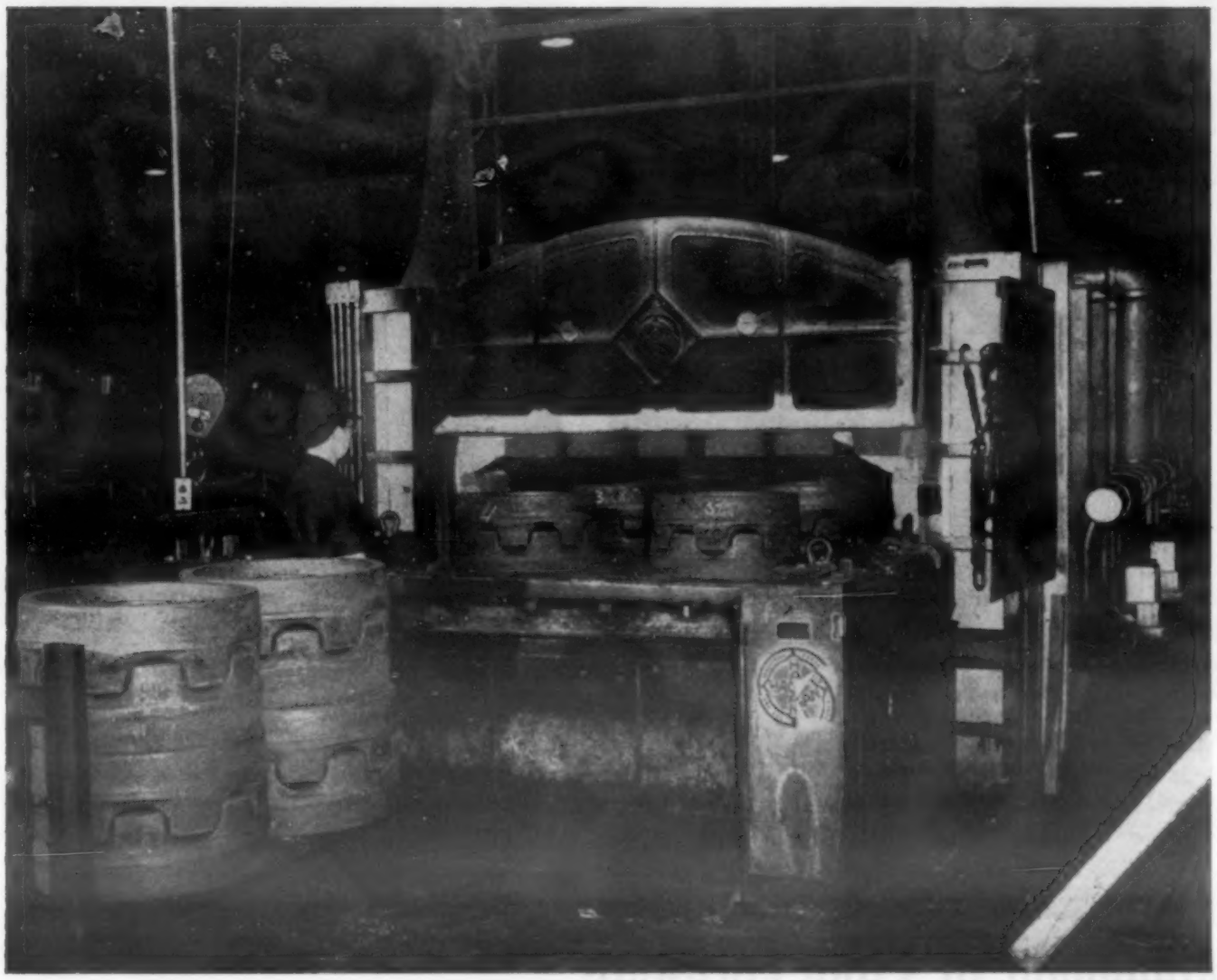
Cyclic Annealing of Steel Forgings Saves Time, Betters Quality

by **KENNETH ROSE**, Engineering Editor, Materials & Methods

WHEN STUDIES HAD SHOWN the effect of time and temperature in the transformation of the structural constituents of steel, and the "S-curves" had been plotted, these rates of transformation of austenite to the structural constituents at temperatures within the usable ranges were quickly applied to the hardening and tempering process. It became possible to control the hardening and tempering of steel when its composition was known by correlating the practice of quenching with the theoretical rates of transformation. Application of this knowledge of transformation rates has made it possible to control the cooling of steel during quenching, particularly through those ranges where a change in volume accompanies the transformation, and so to achieve practically distortionless quenching.

Close control over time and temperature can result in better annealing of steel forgings with a considerable speeding up of the entire process.

This is a far cry from the former practice of cooling steel of most types as quickly as possible without cracking, and letting the size of the workpiece or the nature of the quenching medium provide the only regulation of cooling rate. For the most part, it has meant that the cooling rate could be slowed through critical parts of the quenching cycle, and warping reduced or eliminated. Finishing to closer tolerances before hardening has been made possible as a result of this reduced warpage.



(2) Aircraft engine crankcases of forged steel are cycle annealed at Wyman-Gordon Co.'s Worcester plant with a considerable saving of time and improvement of results.

Knowledge of the transformation rates of steel at given temperatures has been applied to the process for obtaining the opposite effect to hardening in steel also. Annealing has always been a process in which steel was heated to a high temperature and cooled as slowly as conditions would permit. Slow cooling has sometimes meant 36 hr. in a bell furnace for large ingots. It has seldom meant less than 8 hr. of cooling in some sort of insulation, even for small parts. All of this has meant a slower handling and processing of the material, and usually the use of equipment for many hours, sometimes requiring additional fuel as well.

With the knowledge of the rates of transformation of the constituents, it has been recognized that much of the time during which equipment and material have been tied up to obtain a uniform slow cooling has been wasted. That is, the transformation desired may have been completed, and additional slow cooling through temperatures at which nothing is happening in the steel represents time and money lost. As a means of utilizing this knowledge in the annealing of steel, cooling cycles have been worked out for the standard grades of steel. Cyclic annealing has been used by several companies for six years or more, and others have recent installations or installations planned.

A considerable amount of time can be saved in most cases by proper application of the knowledge of transformation rates to the annealing process. Cycles that have been worked out for the recent installations frequently show reductions of 50% or more of the time formerly required. The savings that can be made during the annealing of large ingots are quite substantial. It is impossible to make any overall estimate of savings, because annealing practice in the past has not been uniform, nor equally efficient from plant to plant.

The annealing cycle must be fixed for each type of steel from its transformation rates. The limitations of the furnace are important here, for an inefficient heating unit can affect the time required for any given cycle considerably. An antiquated furnace that does not permit rapid heating or cooling, or one in which the temperature is not uniform throughout the mass of the work, can make efficient cyclic annealing impossible.

A generalized cycle for annealing might be as follows:

(1) Austenitizing. The work is heated to a temperature of between 1450 F and 1700 F, depending upon the composition of the steel, and upon whether the final structure is to be spheroidal or lamellar. The

(3) The three zones in the furnace are clearly shown in this view. (Wyman-Gordon Co.)

most common temperature is about 1600 F. The holding time at this temperature will depend upon the size of the work, but 1 hr. is common for small pieces.

(2) Cooling through the transformation range. This can be done in several steps. The spread of transformation temperatures for most production steels will lie between 1300 and 1000 F, and time and temperature, selected from the transformation-time-temperature curve, must be accurately regulated. It is here that the annealing of the steel takes place, with the transformation of austenite into some desired structure.

(3) Cooling to room temperature. It is often possible to make considerable savings in time here. When the transformation is complete, usually between 1200 F and 1000 F, the remainder of the cooling can be done in the furnace, in air, or in water, as the individual case warrants.

The complete annealing cycle for each steel is worked out from its transformation-time-temperature curve, called "T-T-T curve," or "S-curve." The temperature for austenitizing is first fixed, and a time decided upon that will assure complete austenitizing. The size of the workpiece and the uniformity of heating in the furnace if oil- or gas-fired are factors to be considered. Rate of transformation is then determined from the curve, and a time about 50% greater is usually fixed upon to allow for any fluctuations in temperature or for other conditions.

When the temperature range in which transformation can be completed in a relatively short time is narrow, it is usually desirable to transform by continuous cooling at a uniform rate. When the range in which transformation occurs in a relatively short time is broad—say about 100 F—then rapid cooling to within this range, and isothermal treatment to complete the transformation, are advantageous. Transfer to a salt bath at the desired temperature, or to another zone in a fired furnace, are the methods usually used in the latter case. When the change has been completed the work may be cooled in another zone in the furnace, or set outside to cool, or it may be dumped into oil or water, depending upon the individual case.

Cyclic annealing can be accomplished with any type of equipment that will permit the required close control of time and temperature. Open-fired furnaces, controlled atmosphere furnaces, or salt bath furnaces are being used effectively.

Wyman-Gordon Co., one of the early users of cyclic annealing, treats large and small forgings of SAE 4140 and SAE 4340 steel in an oil-fired zone furnace. Aircraft engine crankcases, crankshafts, propeller

shafts, and propeller hubs are so annealed. The furnace consists of three zones, combined into a single unit, and handling 1600 lb. of work per hr. Temperatures are automatically controlled in both heating and holding zones, and the work is fed through on trays, moved over a roller rail hearth by pushers, also automatically timed.

The annealing cycle for SAE 4340 steel is:

(1) Heating—to 1700 F—4 hr.
(2) Hold at 1700 F—1 hr.
(3) Quick cool to 1200 F—1½ hr.
(4) Hold at 1200 F—12 hr. (min.)

For SAE 4140 steel, the annealing cycle is:

(1) Heating—to 1650 F—2½ hr.
(2) Hold at 1650 F—1 hr.
(3) Quick cool to 1200 F—1 hr.
(4) Hold at 1200 F—8 hr. (min.)

The company reports that cyclic annealing is especially helpful with the 4340 composition. Former practice had required a slow cool in the furnace from normalizing temperature, taking as much as two days, and even then average hardness was higher than desired. Brinell values were about 248 to 255, and hardness was very nonuniform. The present process produces parts with a maximum hardness of 228 Brinell, and with good uniformity. While SAE 4140 was annealed without difficulty by the older methods, the present operation is more adaptable to the production line, and the work is of more uniform hardness.

Cadillac Motor Car Div. of General Motors uses a normalizing treatment to prepare forgings for machining. The process is accomplished in a four-zone furnace in which the forged parts are heated to a temperature about 100 F above the upper critical point of the steel, cooled rapidly by means of air-cooled tubes to a lower temperature, and then gradually cooled to room temperature. The furnace is completely automatic, with the input of heat to each zone controlled by means of potentiometers, and a clock actuated hydraulic pushing mechanism to move the work.

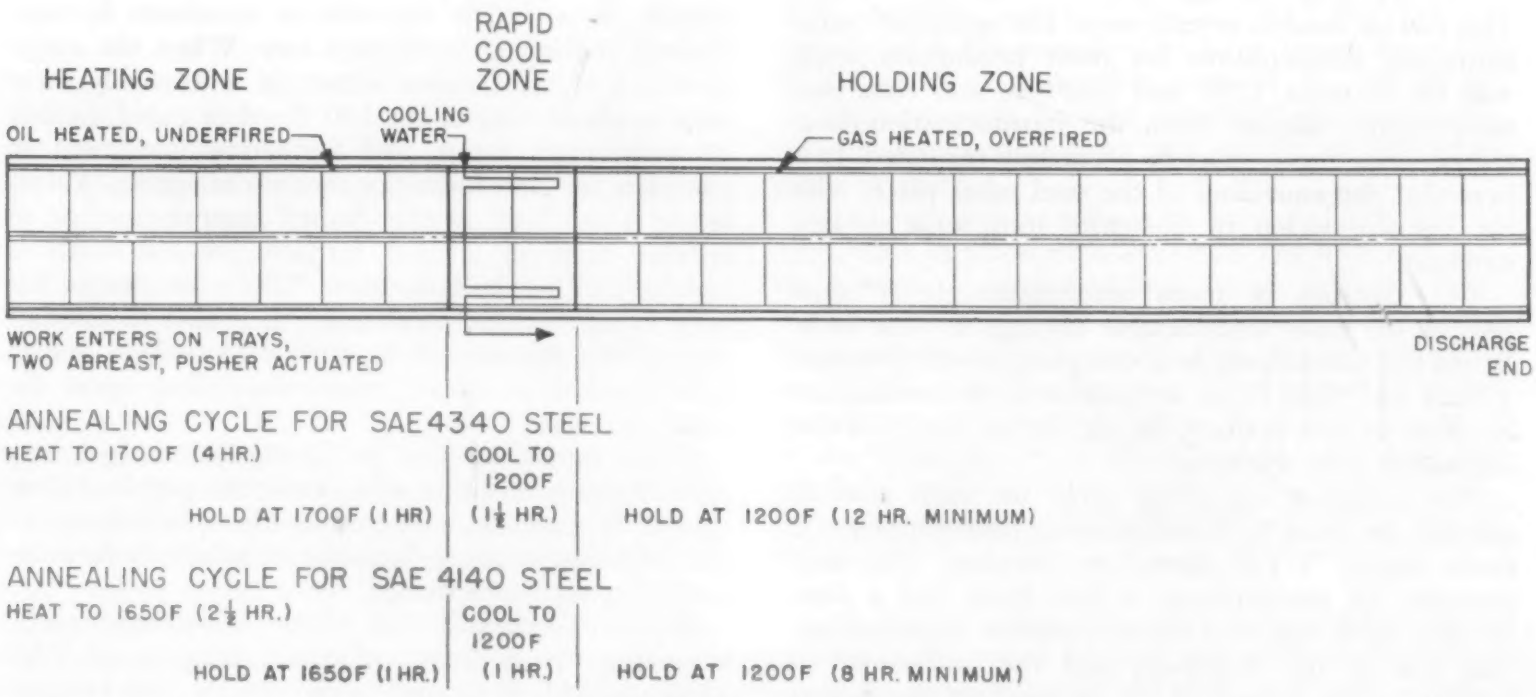
In another installation, at Eaton Manufacturing Co.'s Axle Div., a controlled atmosphere furnace is used to anneal purchased forgings preparatory to machining. The forgings have been cleaned before arrival at the plant, so a protective atmosphere is used to prevent scaling. A four-zone radiant tube gas-fired furnace austenitizes the pieces, of A4817 steel, at 1700 F for 30 min. They are then cooled quickly to 1200 F, and in the next zone cool slowly to 900 F. The temperature in the fourth zone is 600 F, after which the work moves into the open air to cool to room temperature.

The complete cycle in the furnace requires 14 hr. The furnace handles about 1200 lb. per hr. of forgings, net.

Salt bath furnaces are well adapted to cyclic annealing, as an essential feature of the process is that temperatures must be accurately controlled, and must be uniform throughout the mass of work. Zones can be set apart sharply when using salt baths, and heat quickly dissipated from the work.

A large salt bath furnace installation to anneal gear blanks and other forged parts preparatory to machining is being made by the Ford Motor Co. This method takes advantage of the short time required fully to anneal such parts when the transformation is carried out at constant temperatures.

Early patents upon cyclic annealing were obtained by Peter Payson of Crucible Steel Co. of America, and were assigned to that company. These patents were granted in 1940 and 1941, and some companies have been making use of the process since that time as licensees. Crucible Steel Co. has been generous in the matter of licensing.


RAPID COOL ZONE
HEATING ZONE
HOLDING ZONE
COOLING WATER
OIL HEATED, UNDERFIRED
GAS HEATED, OVERFIRED
WORK ENTERS ON TRAYS, TWO ABREAST, PUSHER ACTUATED
DISCHARGE END
ANNEALING CYCLE FOR SAE4340 STEEL
HEAT TO 1700F (4 HR.)
HOLD AT 1700F (1 HR)
COOL TO 1200F (1½ HR.)
HOLD AT 1200F (12 HR. MINIMUM)
ANNEALING CYCLE FOR SAE 4140 STEEL
HEAT TO 1650F (2½ HR.)
HOLD AT 1650F (1 HR.)
COOL TO 1200F (1 HR.)
HOLD AT 1200F (8 HR. MINIMUM)

(4) A typical flow diagram of a cycle annealing furnace.

Metallic Titanium is Light, Strong, Durable, and Corrosion Resistant

by E. A. GEE, Assistant Chief, Metallurgical Division, J. R. LONG, Senior Metallurgist, and W. H. WAGGAMAN, Senior Mineral Technologist, U. S. Bureau of Mines

UNTIL QUITE RECENTLY the metal titanium has not been given consideration as a structural material because early workers had indicated that it was a hard, brittle metal with little likelihood of possessing properties of engineering value. However, it has since been demonstrated that the metal in the pure form is not only ductile, but has a very desirable combination of physical and mechanical properties.

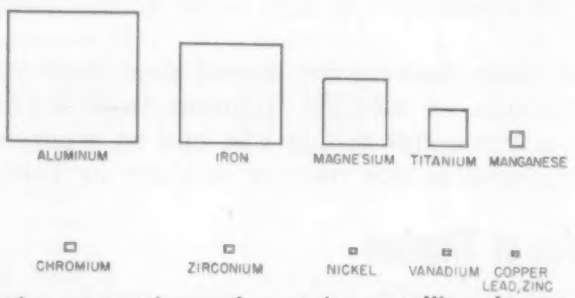
It is light, strong, and resistant to corrosion, properties which are of paramount import to designers and users of modern equipment, because of the ever increasing demand for light-weight, high-speed machines. While it is not expected that titanium will displace iron or structural steel as a universal material for low cost construction, or that it can compete in all cases with aluminum or magnesium, this new metal will undoubtedly find many important applications in the field of engineering that are now only partially filled by the ordinary materials of construction.

Supply of Raw Materials

Titanium is the fourth most plentiful structural metal in the earth's crust, being exceeded by iron, aluminum and magnesium.

The relatively large amounts of iron, aluminum, magnesium and titanium potentially available, as compared to the small amounts of such metals as copper, zinc and lead, are most striking.

The main commercial ore of titanium is ilmenite or titanate of iron ($FeTiO_3$), and deposits of ores containing this mineral that are amenable to concentration are widely distributed. Prior to World War II, the bulk of the ilmenite used in this country was imported from India, but the United States possesses large reserves of ilmenite in the Adirondack region of New York, and there are other deposits in Wyoming, Virginia and Arkansas. The beach sands of the Florida East coast contain many millions of tons of ilmenite as well as other heavy minerals which are now being successfully recovered by standard beneficiation methods. Rutile or titanium dioxide, the other important mineral of titanium, is by no means as plentiful as ilmenite, but substantial deposits which occur in Virginia are being successfully exploited.



Relative proportions of certain metallic elements in earth's crust (lithosphere).

Up to the present time the main use for titanium minerals has been in the nonmetallic field. Enormous quantities of the oxide are now used in paint, thus relieving the drain on our reserves of lead and zinc, which heretofore have been the basis of the paint industry. Pigments consisting chiefly of precipitated titanium dioxide are exceptionally white, have excellent covering power and little tendency to chalk or discolor when properly prepared. Other nonmetallic uses for titanium are the manufacture of salts for the dyeing industry, for the production of titanium chloride, an unusually effective smoke screen material, for welding rod coatings, and in the production of titanium carbide which has proved very useful as a cutting tool.

Exploitation of titanium metal has lagged despite its exceptional properties and a plentiful supply of titanium-bearing minerals because the metal as initially produced was so contaminated with impurities that its true properties were not known, and because the difficulties encountered in preparing the pure metal were such as to discourage commercial development. Processes are now known by which the ductile metal can be readily and consistently produced, and at least one method has been shown to be applicable to large-scale production. Chemically, titanium is a very active metal and reacts readily with such elements as oxygen, nitrogen and carbon, forming hard compounds which embrittle the metal. Extreme care must, therefore, be taken to avoid contamination with these substances. Hydrogen also embrittles titanium, but this element, unlike the others, can be readily removed from the metal by vacuum treatment and, therefore, creates no difficulties.

The Bureau of Mines has conducted extensive investigations on the preparation of ductile titanium metal and has developed one method to the point of producing titanium in lots of 100 lb. The Bureau

laboratories have also developed methods for consolidation and fabrication of the metal and have determined the properties of the metal thus prepared.

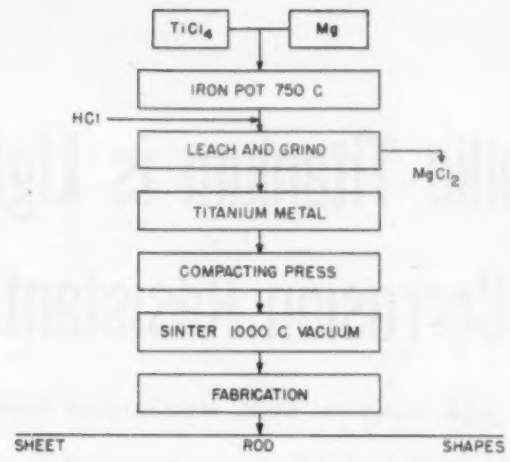
Manufacture of Titanium Metal

The most practical processes yet devised for producing ductile titanium have been developed by Hunter and Kroll, and involve the reduction of titanium tetrachloride by sodium or magnesium. Direct reduction of the titanium from its oxides has not been satisfactory. Reducing agents such as carbon, silicon and aluminum are not suitable because of incomplete reduction and contamination by carbides, oxides, etc.

Titanium metal of very high purity was produced by Van Arkel, using the so-called hot wire method of reducing titanium iodide on a glowing wire. The problems of purification of the titanium iodide and translation of the laboratory process into large-scale production appear prohibitive.

The processes developed by Hunter and Kroll involve the reduction of titanium tetrachloride by means of sodium or magnesium. Hunter's process, using sodium, has not been suitable because of the high pressures encountered during the reduction and the somewhat variable quality of titanium produced. Kroll's process, using magnesium, does not involve high pressures and allows the use of simple apparatus. The product is also quite uniform in quality. The Bureau's work has, therefore, been largely concerned with modification of the Kroll process for the purpose of simplifying it and rendering it suitable for large-scale operation.

The following is a brief description of the apparatus and process now in use at the Boulder City Station:



Flow sheet of titanium metal production.

Table 1—Partial Analysis of Standard Powder[1]

Weight Loss in Sintering Under Vacuum, %	Percent						
	Mg	Fe	Cl	H	N	O	Ti[2]
0.54	0.50	0.09	0.05	0.11	0.017	0.083	99.15

[1] *Analyses made by Boulder City Div., Metallurgical Branch. In addition, the metal contains traces of C, Ca and Si.*

[2] *Titanium determined by difference.*

Table 2—Properties of Metallic Titanium

	Annealed	Cold Worked
Tensile strength, psi.	80,000	120,000
Yield strength—0.2% offset, psi.	67,000	113,000
Proportional limit—0.01% offset, psi.	59,000	84,000
Elongation—% in 2 in.	25	7.5
Young's modulus—psi. x 10^6	16.8	15.4
Rockwell hardness	88B	25C
Electrical resistivity ohms per cm^3 x 10^6	50	52
Density	4.5	4.5

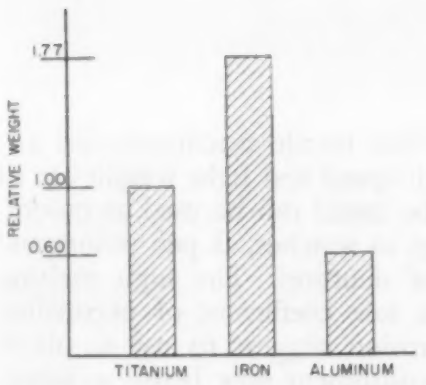
Melting of titanium by conventional means has not been too successful. The molten metal dissolves, reduces, or reacts with all standard crucible materials such as zirconium, thoria, magnesia, calcium oxide, etc., and thereby becomes contaminated. The use of conventional powder metallurgy methods for bonding the material well below the melting point circumvents these difficulties. The clean granular titanium thus produced is pressed into compacts and sintered for 16 hr. under vacuum at a temperature of 1000 C; after this the metal can be rolled into bars and sheets by standard fabricating methods.

Current studies have demonstrated that the metal can be successfully melted in an arc between tungsten electrodes, and ingots about 20 cu. in. in size have been prepared. The melting of titanium is one of the basic problems which must be surmounted if cheap metal is to be produced. Recent research on vacuum melting in graphite have shown some promise, and this technique is now under further investigation.

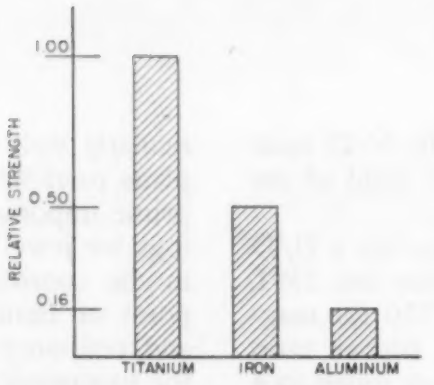
A flow sheet showing the several steps involved in the production of metallic titanium from titanium chloride accompanies this article, and an analysis of metal produced in this manner is given in Table 1.

Properties of Titanium

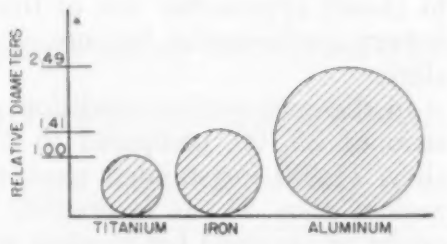
The properties of titanium as compacted by powder metallurgy techniques and rolled into thin sheet are



Relative weight of equivalent volumes of titanium, iron, and aluminum.



Strength of titanium compared to iron and aluminum.



Diameters of titanium, iron and aluminum bars of equivalent strength.

given in Table 2. In the annealed state, the properties of titanium are excellent; the tensile strength of 80,000 psi., yield strength of 67,000 psi., Rockwell hardness of B-88, and elongation of 25% are considerably better than those possessed by other common pure metals in the annealed state. There are, however, many commercial alloys and heat-treated sheets whose properties exceed these values, but a true comparison cannot be made with these materials, since the properties of titanium-rich alloys have not been determined. Considerable study is now being devoted to alloys of titanium with many other metals, but data concerning the desirable alloy combinations and resulting properties are not yet available. It is known, however, that titanium will readily alloy with many metals and that selected alloys will undoubtedly be amenable to heat-treatment in a manner similar to steel. It is too early to predict just what the investigations of the alloys of titanium will bring forth, but in the case of nearly every other metallic element this field of research has yielded products having physical and chemical properties superior in many respects to the metal alone. There is no reason to believe that alloys of titanium will prove an exception to this rule.

A comparison of the properties of annealed titanium with those of pure iron and aluminum is diagrammatically shown in accompanying illustrations. One illustration emphasizes the low specific gravity of titanium (4.5 compared to 7.9 of iron) and shows that the same volume of iron weighs 1.77 times as much as titanium and that aluminum has 0.6 as much weight.

The comparative strengths of these metals indicate that titanium has twice the strength of iron and approximately 6 times the strength of aluminum. In bars having equivalent strength, if the titanium bar is to be taken as 1-in. dia. an iron bar would have a diameter of 1.41 in. and one of aluminum 2.49 in.

The metal, although hexagonal and therefore not as plastic as the cubic metals, can be readily cold-worked by standard methods. Cold-rolled sheet with reductions of up to 40% in thickness has a tensile strength of 120,000 psi., yield strength of 87,000 psi., Rockwell hardness of C-25, and 7.5% elongation. These are also excellent properties for cold-worked metal and suggest that the cold-worked material can be successfully used without encountering failures.

Another comparison of weight strength relationships of titanium with 2S aluminum, magnesium, 23ST aluminum, magnesium, alloy M, and stainless steel is given in Table 3. In this table, the properties of titanium are compared with handbook values for the other materials. The comparison is not necessarily exact, since none of the metals are represented by their maximum properties, and titanium is represented only in the form of the pure metal, but nevertheless such consideration is useful in any evaluation of the possibilities of titanium.

The first portion of the table is concerned with annealed material and shows that titanium with an ultimate strength/density ratio of 17,800 is surpassed only by the 23ST alloy because of the latter's high strength and low density. The yield strength-density ratio of titanium is also exceeded by that of 23ST alloy, and while the U/D ratio of magnesium alloy

Table 3—Weight-Strength Data

	Condition	Ultimate Strength, Psi.	Yield* Strength, Psi.	Density	U/D	Y/D	Elongation
Titanium	Annealed	80,000	64,000	4.5	17,800	14,200	25
Aluminum 2S	Annealed	13,000	5,000	2.7	4,815	1,852	35
Magnesium	Annealed	25,000	—	1.74	14,390	—	5
23ST Alloy	Heat treated	68,000	44,000	2.76	24,630	15,940	19
Mg Alloy M	Annealed	32,000	16,000	1.8	17,770	8,890	19
Stainless Steel	Annealed	95,000	45,000	7.91	12,000	5,690	55
Titanium	Cold worked	120,000	113,000	4.5	25,700	25,100	7.5
Aluminum 2S	Hard rolled	24,000	21,000	2.7	8,890	7,780	5
23ST Alloy	Hard rolled	70,000	55,000	2.76	25,370	19,920	13
Mg Alloy M	Hard rolled	37,000	27,000	1.8	20,550	15,000	9
Stainless Steel	Hard rolled	185,000	140,000	7.91	23,400	17,700	8

* *Yield strength corresponding to 0.2% effect.*

M closely approaches that of titanium, its Y/D ratio is very much smaller because of the low yield of the alloy.

In the cold-worked condition, titanium has a U/D ratio of 25,700, compared to 25,370 for the 23ST alloy, 23,400 for stainless steel, and 20,550 for magnesium alloy M. It is possible that a higher ratio might be obtained for stainless steel when rolled to a greater degree, but this would drop the ductility below a figure comparable to that of the titanium. Because of the relatively high yield strength-ultimate strength ratio, the Y/D of the other worked materials falls considerably below that of titanium, which shows a value of 25,100 and is approached only by the 23ST hard-rolled alloy with a value of 19,920.

It would appear from these results that in spite of the fact that information is available on pure titanium only, the metal can compare quite favorably with highly perfected alloys as a construction material on a strength-weight basis.

Corrosion Resistance

The high corrosion resistance shown by titanium, despite the great chemical activity of the metal, is undoubtedly due to the formation of an impenetrable adherent oxide coating. It appears that this coating is readily formed on simple exposure of the metal at room temperature and protects it from further attack. While detailed information is not yet available, it is known that the metal is inert to concentrated nitric acid, and that 5% solutions of HCl, NH_4OH, NaOH, and acetic acid do not cause loss in weight in excess of 0.05 mg. per sq. dm. per day. Titanium is, however, soluble in higher concentrations of HCl and is readily attacked by sulfuric acid. On the other hand, exposure in a salt spray chamber for 30 days produced no visible signs of attack on either annealed or cold-worked metals. The tensile properties of specimens so exposed were essentially the same as the control samples.

Finely divided titanium powder, like many other metals, is pyrophoric, but the consolidated metal is quite stable. Although very fine wire can be ignited in a Bunsen burner, in larger sizes, titanium wire simply undergoes slow oxidation. Massive pieces of the metal can be ignited by heating in a stream of oxygen, but will not continue to burn if the oxygen is withdrawn.

Present and Potential Uses of Ductile Titanium

Up to the present time, the small production of ductile titanium has limited its industrial applications. In the form of rods it has been used to produce spectra for astronomical research, and filaments of titanium have been employed in electric light bulbs. The metal's unusual combination of properties, however, suggest a wide variety of uses, some of which already have been established while others are being thoroughly investigated.

Since titanium can be surface-hardened, it has a distinct advantage over the other light metals for equipment subject to frictional wear. It appears particularly well adapted for textile machinery and airplane parts where high speed and light weight are of prime importance. The metal can be used as mountings for jewel bearings in watches, as pen points and in the construction of dentures. The high melting point of titanium, its low coefficient of expansion, and resistance to corrosion suggest its use in alloys for supersonic speed equipment now being so intensively studied. The pure metal can be employed in the preparation of master alloys from which titanium alloys of definite composition can be produced. Not only is titanium suitable for filaments, but because of its ability to absorb nitrogen and oxygen, it acts as a permanent "getter" in vacuum tubes. Other suggested outlets for metallic titanium are in the manufacture of pyrophoric flints, thermocouples and cladding for other metals.

No accurate estimates of the cost of producing titanium can be made. At the present time, it is believed that on a small scale titanium can be produced for $3.00 to $4.00 a lb., and estimates of large scale production have been as low as 50¢ a lb. Even at the higher prices, the unusual and valuable properties of titanium are such as to amply justify its use for purposes that cannot be adequately fulfilled by other metals. The technology of titanium however, is only in its infancy, and continued improvement of the preparation and fabrication processes will eventually bring about lower costs.

When it is considered that titanium in the form of ilmenite costs only 4¢ a lb., while in the form of chloride the element costs $1.04 a lb., it can be seen readily that the simplification of the present processing steps would result in a substantial reduction in the price of this metal.

By looking back about 60 years we find that aluminum and magnesium now quoted at 15¢ and 20½¢ per lb., sold for $7.50 and $10.00 per lb., respectively. The decrease in the price of these metals over their relatively short history is an example of what improvements in metallurgical processing can accomplish.

This development is part of the Bureau of Mines research program in the field of metallurgy. Small scale research on new and rarer metals is translated to process pilot plants where quantities ranging from a few pounds to many tons are produced. The present Boulder City, Nevada titanium pilot plant is an example of this program. During the past two years it has been the policy of the Bureau of Mines to distribute new metals to qualified technical and scientific organizations in order to expedite industrial interest and exploitation, feeling that in so doing, the Bureau was performing a function of importance to the development of the national economy. It is believed that by actual demonstration of the properties of these metals, sufficient demand will arise to attract private enterprise. Patents resulting from such studies are, of course, available to industry by nonexclusive licensing without fee.

As the technology of metallic titanium advances and further data becomes available, the Bureau of Mines will release this information for the benefit of the metal industries.

The demand for better materials in automotive engines resulted in a new alloy cast iron which attains its properties through casting and heat treating methods.

Centrifugal Casting Proves Advantageous for Iron Piston Rings

by **TRACY C. JARRETT & ERLE J. HUBBARD,** Manager of Research, and Asst. Chief Metallurgist, Koppers Co., Inc., Piston Ring Div.

AS DESCRIBED PREVIOUSLY, nearly all piston rings have formerly been made from a good grade of statically cast gray iron. With the advent of the war, great demands were made upon the piston ring industry to produce piston rings that would aid in developing engines with greater output. Through the medium of research, the first step to improve materials to meet this demand was in the alloying of individually cast piston rings. However, individual cast gray iron piston rings are limited in their physical properties due to the material and the method by which they are made. New and improved engines have made it necessary to develop a new material for piston rings that will possess properties exceeding the current demands of industry.

Several methods of producing such a material were tried and it was found that the process of centrifugal casting proved to be the most desirable. This method has been used for such articles as cylinder sleeves but is relatively new to the piston ring industry in this country. From the beginning of the development of this process, it was apparent that greater flexibility, both in ring characteristics and materials, could be secured. A composition, proving to be superior in many ways, was finally chosen as a result of the laboratory and field tests. The chemical and physical properties of this new material and those for standard gray iron piston rings are listed in Table 1.

This material when spun solidifies as white iron (Fig. 1) and then is heat treated to bring about the microstructure as shown in Fig. 2. The distribution and type of the graphite of the high tensile iron is entirely different from that in gray iron (Fig. 3). The matrix in the high tensile material is of the tempered martensitic type, whereas in gray iron it is fine pearlite.

The centrifugally cast material, which is fine grained, is used in industrial applications such as aircraft, automotive, diesels, etc., but is not recommended for such applications as steam and natural gas engines where an open grained material is more desirable.

Because of the wide range of sizes of centrifugal castings needed for piston ring manufacture, a centrifugal casting unit must be flexible in design to allow as much control as possible. A typical unit for centrifugal casting of piston ring sleeves with the layout of melting units, casting machines, mold processing tables, etc. is shown in Fig. 4. The desired charge to produce the composition shown in Table 1 is melted in 200-, 300- and 500-lb.-capacity electric induction furnaces. A 300-lb. charge of raw material is melted to the pouring temperature in less than 30 min. In-

Table 1—Comparison of Chemical and Physical Properties Centrifugally Cast and Standard Gray Cast Iron Piston Ring Materials

Typical Chemical Analysis		
	Standard Gray Cast Iron	Centrifugally Cast
Total Carbon	3.85	3.20
Silicon	2.75	1.25
Phosphorus	0.40	0.12
Sulfur	0.08	0.035
Manganese	0.51	0.66
Copper	—	0.55
Molybdenum	—	0.50
Typical Physical Properties		
	Standard Gray Cast Iron	Centrifugally Cast
Tensile Strength	42,000 psi.	96,500 psi.
Elastic Modulus	12.0×10^6 psi.	21.0×10^6 psi.
Rockwell Hardness	100 - "B"	26 - "C"
Izod Impact	*2½ - 3½ in. - lb.	*15.0 in. - lb.

** 0.140 x 0.260 section.*

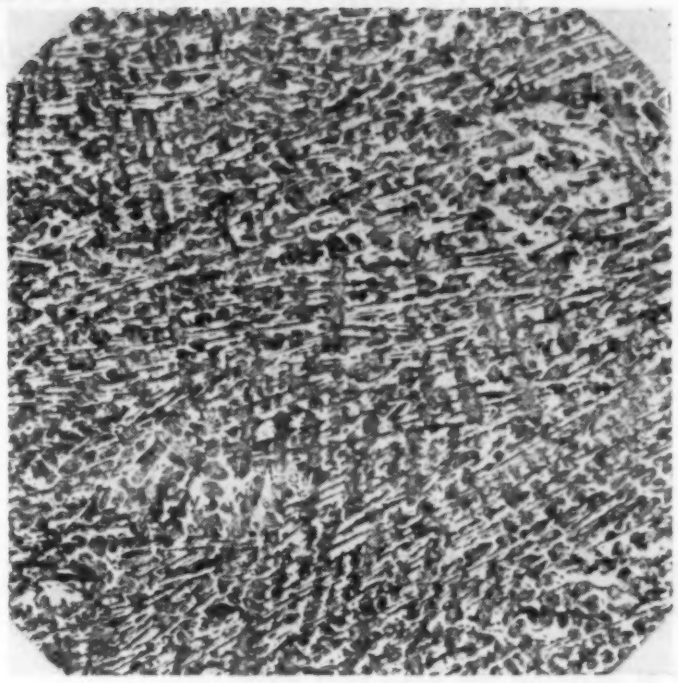


Fig. 1—As-cast structure of centrifugally cast high tensile iron. (100 X; picral etch.)

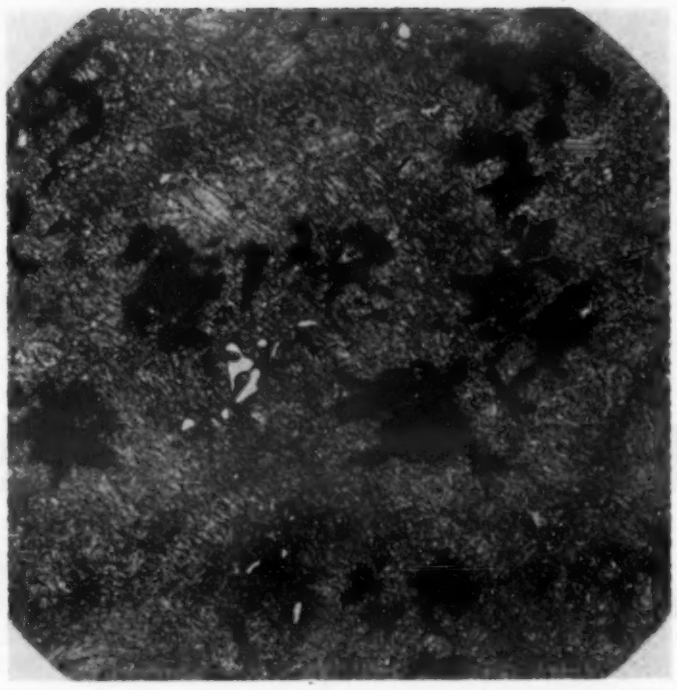


Fig. 2—Structure of centrifugally cast high tensile iron after heat treatment. (250 X; picral etch.)

duction furnaces of this design allow very accurate control over the chemical composition at all times. The spinning machines are equipped with automatic timing and also variable speed control in the range 300 rpm. to 1600 rpm., as different size castings require varying spinning speeds, depending upon the casting wall thickness and diameter.

To obtain the quality of centrifugal castings desired for piston rings, somewhat greater control is necessary over mold temperature and centrifugal casting techniques than under normal permanent mold centrifugal casting methods, as metal removal in machining must be held to a minimum. The standard machining allowance for this metal composition is 3/16 in. on the inside dia. and 5/32 in. on the outside dia.

Experience obtained from centrifugally casting this white cast iron indicated that the temperature of the mold itself should not exceed 600 F during the casting cycle. Excessive mold temperature reduces the cooling or chilling rate of the metal resulting in varying as-cast structures and necessitating other changes in casting technique such as spinning speed and pouring temperatures. A number of castings, however, are obtained from each permanent mold before it is necessary to cool, depending upon the size and weight of the casting. During the casting cycle, when mold temperatures approach 600 F, as indicated by a contact pyrometer, the molds are disassembled, cooled, sprayed

Fig. 5

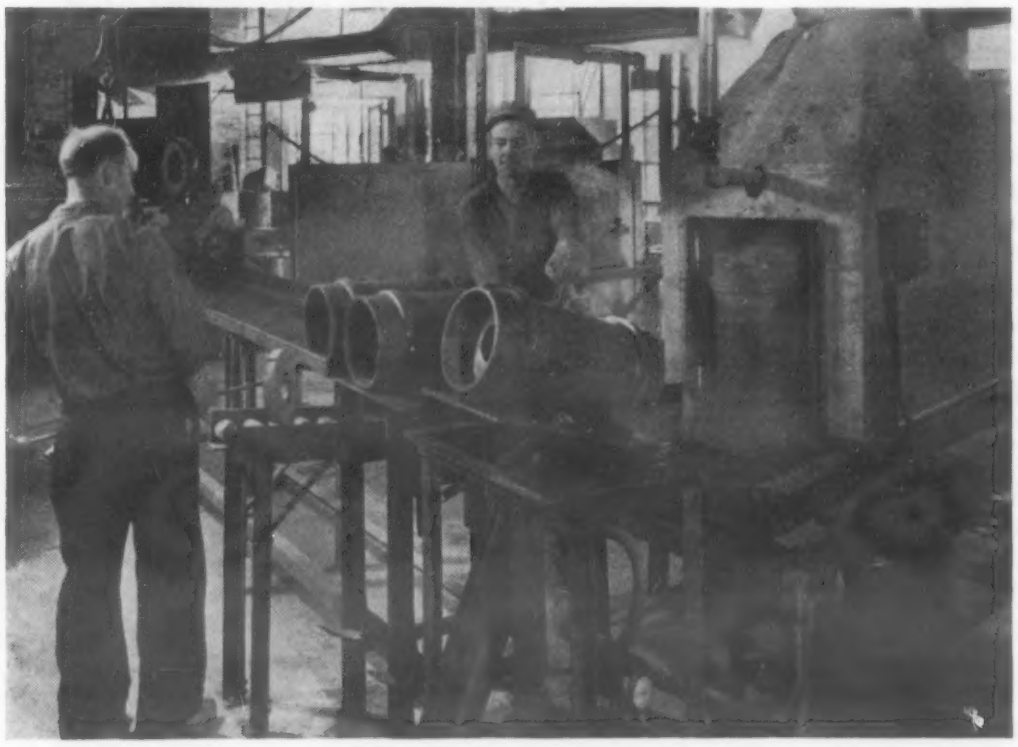


Fig. 6

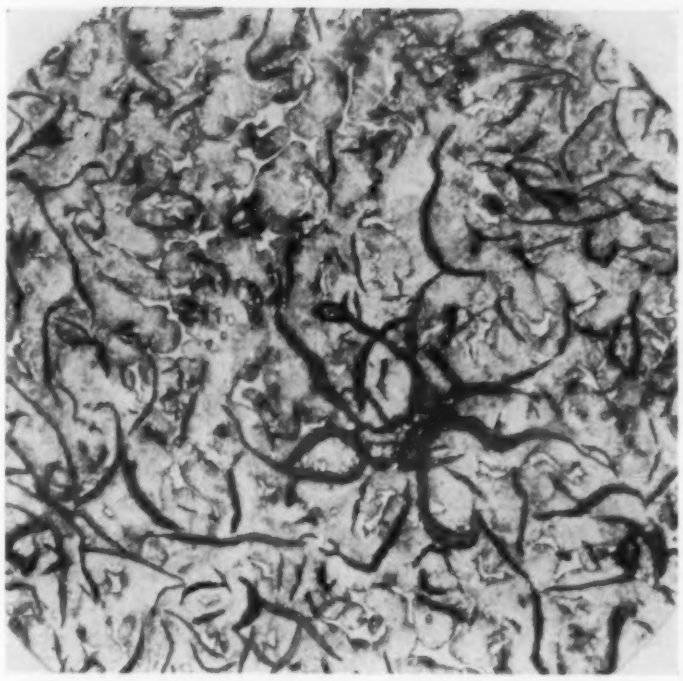


Fig. 3—For comparison, here is the structure of gray iron.

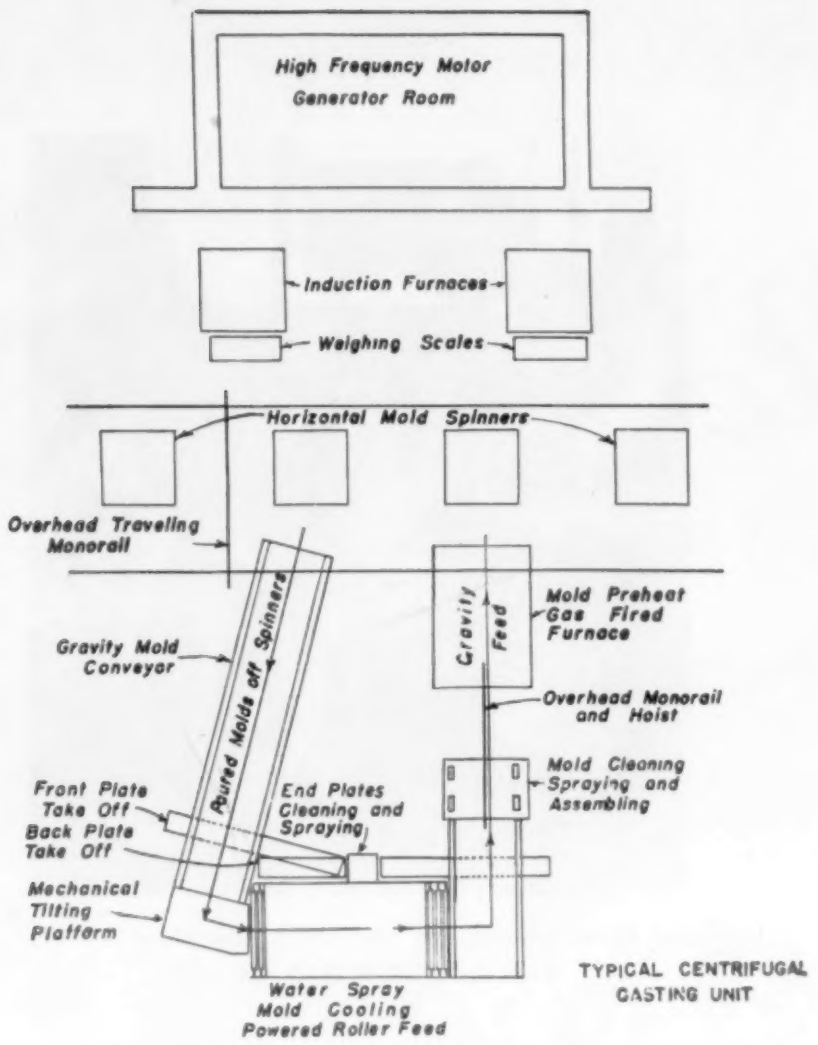


Fig. 4—This is a typical centrifugal casting set-up for producing sleeves used in making piston rings.

and reheated in a gas fired oven to the proper mold temperature before being used for another casting. Fig. 5 shows the cooling unit with heating oven in rear. A number of permanent molds may be processed through this unit at one time affording almost continuous casting, depending upon the supply of molten metal made available by the induction melting furnaces.

The inside diameter of the centrifugal casting is controlled by the weight of the molten metal poured. Molten metal at 2650 F is weighed accurately into small pouring ladles to ½-lb. tolerance, using a special scale installed in a pit adjacent to the melting furnaces (Fig. 6). The weighed molten metal is then poured through a preheated cast iron pouring spout into the spinning mold (Fig. 7). This method of weighing and pouring enables the operator to control the I.D. of a centrifugal casting to an accuracy of 1/32-in.

Fig. 7

Fig. 5—(left)—In this view, the workmen are cleaning and preparing molds for centrifugal casting. Fig. 6 (center)—Induction melted molten iron is being weighed preparatory to casting. Fig. 7 (right)—Sleeves are cast in this line. At left a workman is pouring iron into the mold.

Fig. 8—In this view, the workman is removing a centrifugally cast sleeve from the mold.

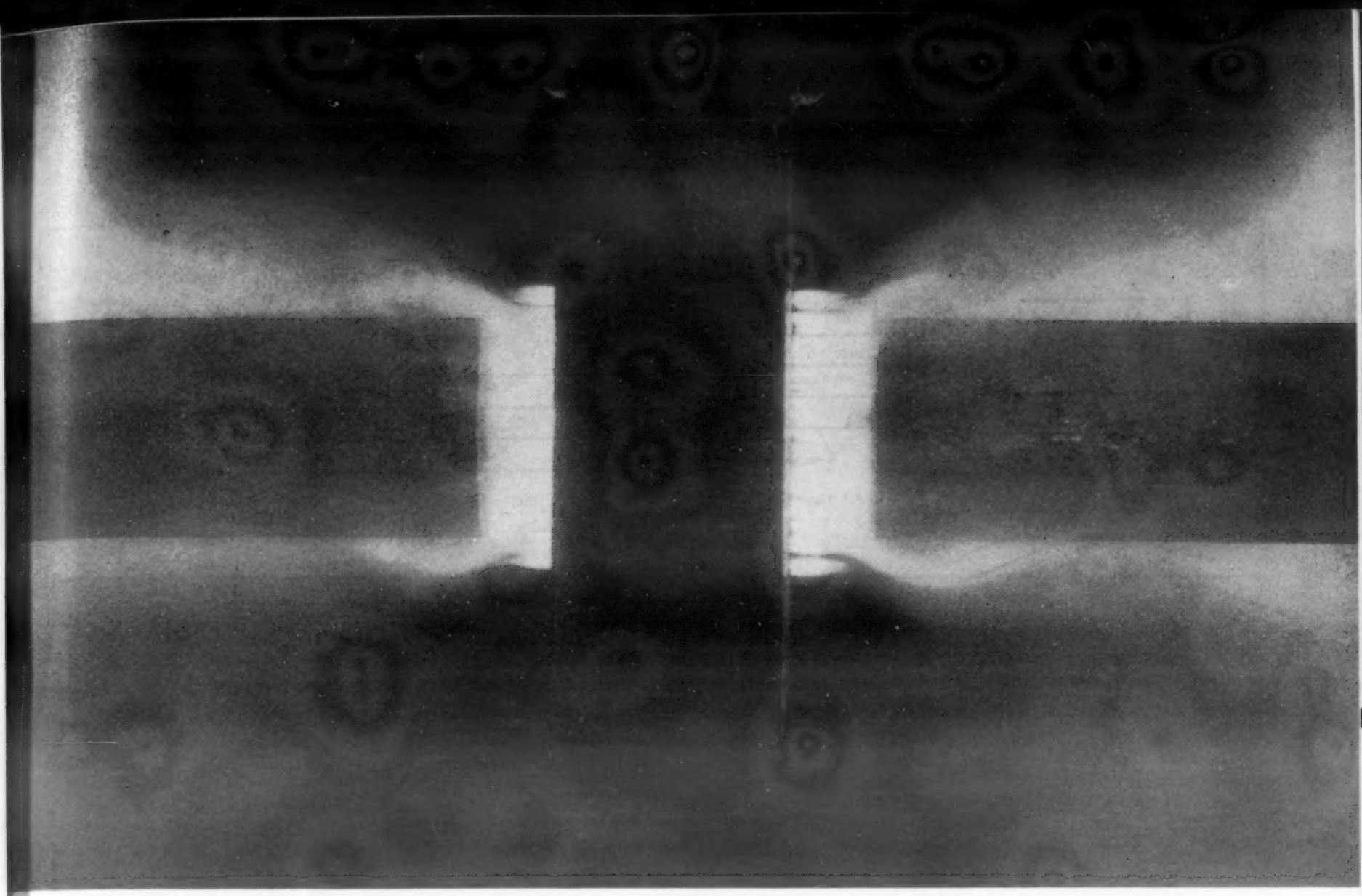
The spinning cycle is relatively short, as castings for piston ring manufacture rarely exceed a wall of ½-in. However, great care is exercised to prevent vibration of the mold during spinning, as this results in defective castings. After the spinning cycle is completed, removal of the front plate on the mold allows access to the solidified casting, which is removed and cooled in still air to room temperature (Fig. 8).

The casting, at this point, is a chilled white cast iron and, as such, is extremely brittle. These castings are then transferred to a modern heat treating department (Fig. 9) where they are annealed for several hours at 1750 F in a controlled atmosphere electric furnace to break down the combined carbon of the white cast iron to a desired microstructure. After the proper time at annealing temperature, the castings are removed from the high temperature furnace and quenched in violently agitated oil. The material at this point possesses a Rockwell "C" hardness of 55 to 60. The castings are then degreased and placed in a tempering furnace at a temperature slightly below the critical point of the metal for a time necessary to obtain the mechanical properties, as shown in Table 1 and the microstructure of Fig. 2. Representative samples for examination of these properties are taken from each lot of finished heat treated castings.

The piston ring sleeves after heat treatment are sent to the machine shop. Here individual rings are parted from these castings and processed similarly to normal individually cast gray iron rings.

The centrifugal casting process not only eliminates the use of sand but has proven economical in the manufacture of piston rings, as much greater yield is obtained from a centrifugal casting than from the individual static cast gray iron piston ring. Electric melting also eliminates the many variables affecting cupola operations. The total foundry scrap, both in the foundry and in the machine shop, is thereby greatly reduced. These two features are a few of the many advantages that this new method of manufacture has to offer.

Fig. 9—This is the heat treating department where the centrifugally cast sleeves described are processed.



Diagrammatic sketch of setup for open-butt pressure welding. For sections over ⅛ in., burner is placed between the abutting faces; for sections ⅛ in. and under, burner is placed above the faces.

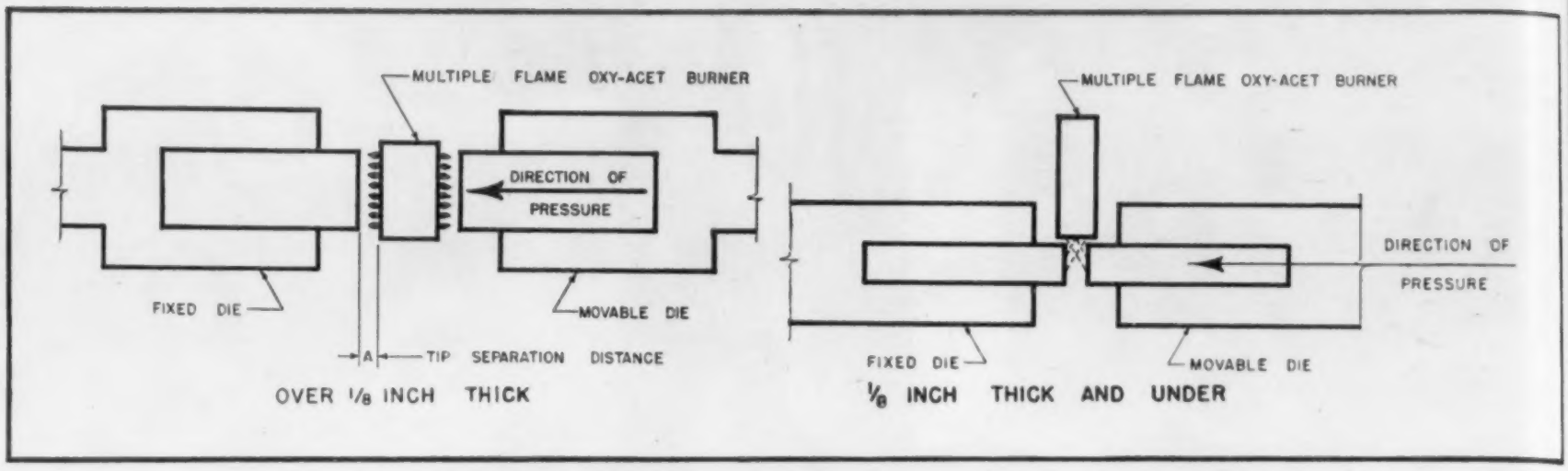
Open-Butt Pressure Welding of Steel

by **H. R. CLAUSER**, Associate Editor, Materials & Methods

A NEW WELDING METHOD, known as open-butt pressure welding, has been developed for butt-joining of ferrous metals. It can be used for joining pipe, tubing, rails, sheet, and a variety of other solid metal sections. It permits the joining of many alloys which are difficult to weld by other methods, and gives a high quality joint at relatively low cost. Open-butt welding has been in development at Air Reduction Sales Co. and Canadian Liquid Air Co., Ltd., of Canada, for several years. Development work is still going on, and although there have been no commercial installations as yet, the process has been thoroughly tested so that a reasonably accurate survey of its possibilities can be made.

In open-butt pressure welding the abutting faces of the parts to be joined are heated by a multi-flame oxyacetylene burner to actual surface melting temperature. The faces are then brought together and pressure is applied to complete the joint. In many respects the process is similar to flash welding except

Wide commercial application is expected for a new oxyacetylene welding process which can be used on a variety of steel types, shapes and forms.



A close up view of the burner heating the faces of 1-in. round bars before welding.

that the heat is applied by an oxyacetylene flame instead of through use of electric power.

The important and distinguishing characteristic of the process is that the abutting faces are heated to their melting point. This is distinctly different from the closed-butt pressure welding method in which the faces of the members to be welded are held together under pressure and heated to some temperature below their melting point. The maximum pressure is applied either at the beginning or end of the heating cycle, or it can be applied gradually during heating. Thus, the joint is made in the solid phase when the metal is in a plastic state rather than in the liquid phase, as is the case in open-butt welding.

Equipment

The major elements of equipment used in open-butt pressure welding are a heat source, pressure equipment, a burner handling device, and control equipment. The heat source is an oxyacetylene flame played on the welding faces by means of a specially designed burner. For sections over ⅛ in., the burner is usually placed between the abutting faces, as shown in an accompanying illustration; for sections ⅛ in. and under, the burner is located outside the joint and the oxyacetylene flames are played on the faces at an angle. In welding large sections or irregular shaped sections the burner can be made up of several small segments to permit easy removal from the joint area.

A burner handling device is required to quickly remove the burner from between the faces when they have been heated to the welding temperature. In some applications it is desirable to have equipment that will oscillate the burner to obtain even heating of the weld faces.

The kind and size of the pressure equipment is largely dependent upon the size and shape of the parts being welded. Either hydraulic and compressed air equipment can be used. In addition, jigs and clamps for holding the work pieces are an essential part of the set-up.

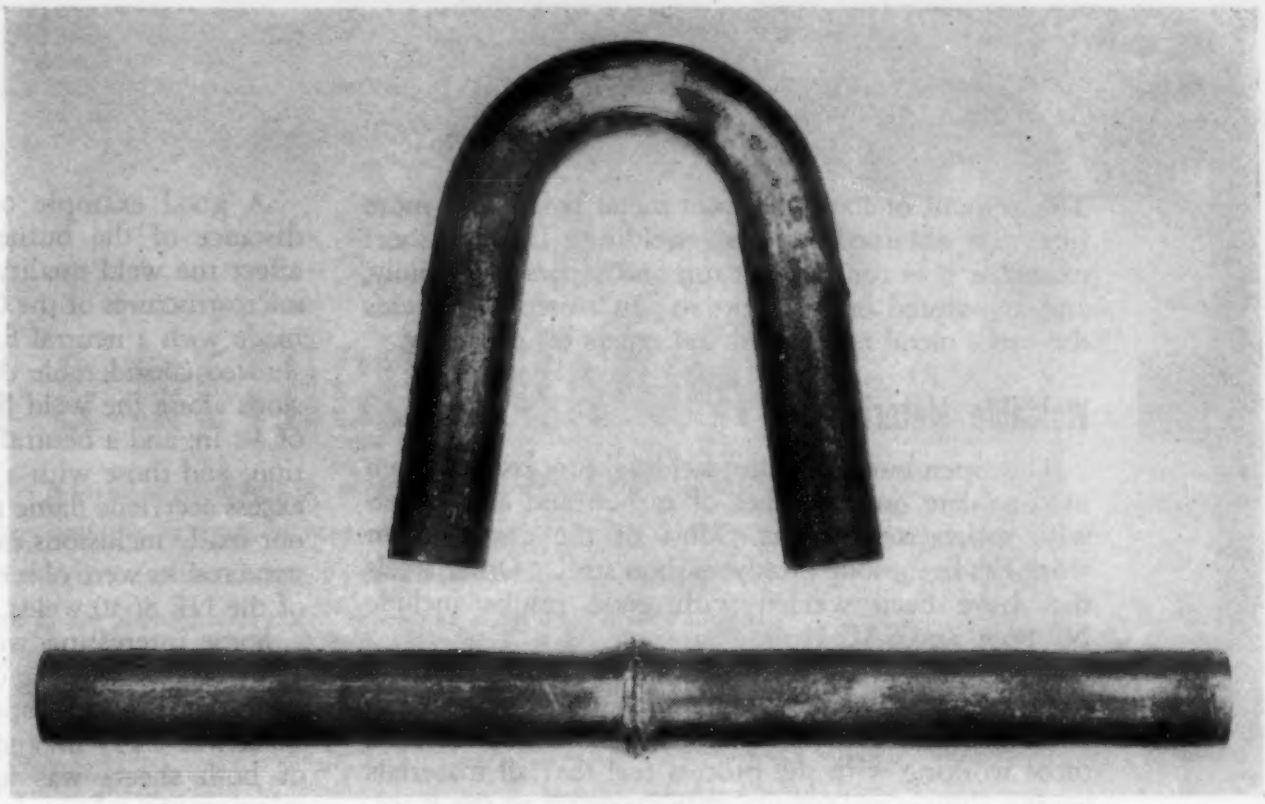
Lighting the burner, removing it from between the faces and bringing the welding surfaces together under pressure are all performed automatically in one continuous operation. The controlling factor is time. The welding cycle is based upon the time necessary to bring the faces to melting, the time needed to remove the burner, and the time required to apply pressure and complete the weld. The control equipment is set at the predetermined times and then it automatically controls the entire operation. In addition, the amount of weld upset is also carefully controlled. Accurate control of the heating time is most essential. For if the pressure is applied too late, the weld will be porous and of poor quality. On the other hand, if it is applied too soon incomplete fusion may result.

Process Characteristics

One of the most important advantages of open-butt welding is that preparation of the faces to be joined is relatively simple. No chemical cleaning is necessary. However, any foreign matter such as scale or rust which will not be burned off by the flame action must, of course, be removed to avoid oxide inclusions in the weld. A surface finish equivalent to that obtained by saw cutting or by shearing is satisfactory, because any small voids or rough spots disappear when the surfaces melt.

As compared to closed-butt pressure welding, preparation of the welding faces is not nearly as critical. In closed-butt welding the faces must have a machined finish and usually be cleaned with organic solvents to insure high strength quality welds. These precautions are necessary so that the welding faces are in intimate contact during the heating phase to avoid oxidation. However, in open-butt welding, since the faces are heated directly, they are protected from oxidation by the flame, and so no such precautions are particularly needed.

The alignment of the abutting faces, as in flash welding and in closed-butt pressure welding, must be accurate to insure both complete contact of the faces when they are brought together, and equal application



Welds in low-carbon steel 1-in. round bars. Upset metal has been removed from the upper bar and subjected to the 180 deg. bend test.

of upsetting pressure along the weld line.

The heating phase is of critical importance in open-butt welding. Two requirements must be taken care of: (1) The abutting faces must be uniformly brought to the fusion point; (2) the composition of the flame must be such that neither decarburization nor oxidation takes place in the weld zone. Both these requirements are met satisfactorily.

The first is achieved largely by maintaining a constant gas flow and by having proper burner design. The burner provides flames that are balanced, and the gases are supplied to the burner at a constant pressure. To obtain this constant pressure and flow of gases, special "pressure equalizers" have been developed. To further insure even heating the burner is sometimes oscillated over the weld faces.

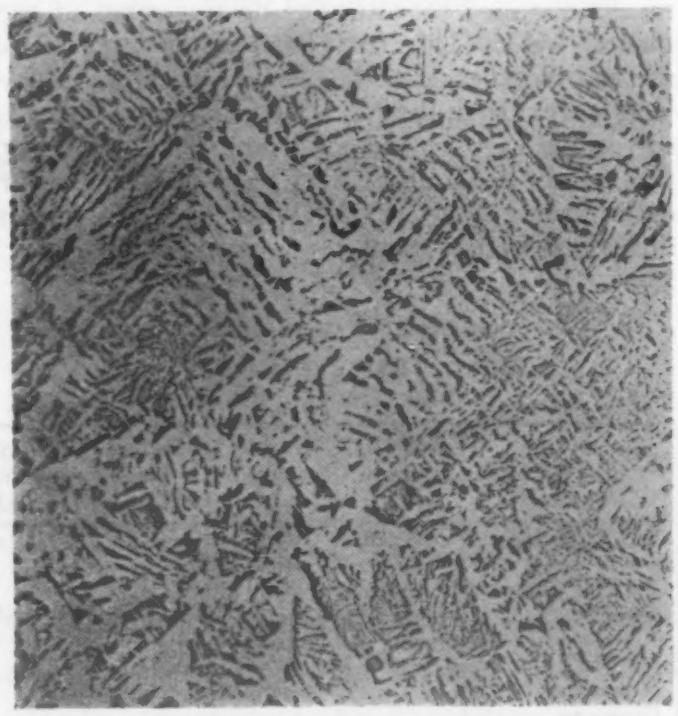
The second requirement is achieved by controlling both the distance of the flame from the weld faces and the composition of the flame. The weld faces are so positioned that they are in the immediate vicinity of the inner cone of the flame. Here the products of combustion are neither oxidizing nor decarburizing; they are actually of a reducing nature and provide a protective atmosphere for the molten metal. A neutral flame is generally used and sometimes a flame with a slight excess of acetylene is used.

By varying the flame composition the properties of the weld can be changed to a certain extent. For example, in welding SAE 1020 steel it was found that a slight excess of acetylene resulted in an increase of impact strength from 11 to 21 ft.-lb. It is believed that future developments will make it possible to give the welded joint certain desired metallurgical properties by varying the chemistry of the flame and by carefully controlling the heating cycle. Some work has already been done in which the carbon content of steel has been increased merely by changing the chemistry of the flame.

Because the faces to be welded are heated directly, open-butt welding is quite rapid and applicable to production work. The heating time is less than that required in closed-butt welding and therefore results in less gas consumption. A 1-in. solid round can be welded in 20 to 30 sec., while a 130-lb. rail (130 lb. per yard) can be welded in 2 min. The welding time for thin sheets is very short: for 0.16-in. sheets, about 5 sec.; for 0.08-in. stock, about 4.5 sec.

The open-butt welding process is also quite flexible. With a single installation a range of section thicknesses and shapes can be welded by merely changing the burner and adjusting the pressing pressure and supply of gas to the burner. Where heat treatment after welding is necessary, the same equipment can be used.

The appearance of open-butt welds is slightly different from those produced by closed-butt welding.



Photomicrograph of a weld in SAE 1020 steel, as-welded. The weld-line running vertical near the center of the picture is barely discernible. (100X)

The amount of flash, or upset metal is less and more like that obtained by flash welding. In thin sheet materials it is rounded on top and tapers off rapidly, and is pointed on the bottom. In closed-butt welds the upset metal is rounded and tapers off gradually.

Weldable Materials

The open-butt pressure welding process has been used to date on a number of carbon and alloy steels with satisfactory results. Most of the development work has been done on low carbon steels. Other steels that have been welded with good results include NE 8630 and SAE 4130.

As yet no work has been done on cast iron, cast steel, or stainless steels, and only a few nonferrous materials have been experimented with. However, those working with the process feel that all materials having similar weldability characteristics to the materials already welded will eventually be found suitable to open-butt welding.

There are practically no limitations on types of cross sections that can be welded. Bar stock, tubes, rectangular sections and rail sections have all been worked on successfully. Miter joints have also been welded; although only 90-deg. joints have been welded thus far, it is believed that no difficulty should be encountered with joints of greater acuteness.

The maximum thickness of section that can be welded is only limited by the equipment available. Present equipment will handle thicknesses up to several inches. The thinnest material thus far welded by the process is reported to be around 0.04 in. Sections of different thicknesses can also be welded. In one case mild steel sheets of 0.039 in. were welded to 0.103-in. sheets of the same composition.

Some Test Results

The accompanying table gives some of the test results obtained by Chiswik[1] on a number of experimental welds. The SAE 1020 welds were tested in the as-welded condition; the high carbon steel welds were normalized; the NE 8630 welds were heat treated to various strength levels. A study of the microstructure of the SAE 1020 steel welds showed a narrow decarburized zone at the weld line; no oxides or inclusions were present.

Mechanical Properties of Some Open-Butt Pressure Welds

Material	Tensile Strength, Psi.	Percent Elongation (in 1 In.)	Guided Bend (Deg.)	Charpy Impact (Ft.-Lb.)
SAE 1020 Steel	67,000	24-27	180	13-16
0.72% Carbon Steel	128,000	8	10	65*
NE 8630 (Quenched and Drawn to 103,000 psi.)	105,000	20	180	21

**Tensile impact*

A good example of how flame composition and distance of the burner tips from the welding face affect the weld quality can be had by a study of the microstructures of the 0.72% carbon steel welds. Those made with a neutral flame and a ⅜-in. tip separation showed considerable decarburization and oxide inclusions along the weld line; those with a tip separation of ¼ in. and a neutral flame showed less decarburization; and those with a tip separation of ⅜ in. and an excess acetylene flame revealed neither decarburization nor oxide inclusions in the weld zone. Essentially the same results were observed from the microphotographs of the NE 8630 welds.

Some interesting work was recently performed by Cuke[2] on the welding of dissimilar thicknesses of mild steel sheet by the open-butt welding method. One sheet was 0.039 in. and the other 0.103 in.; the width of both sheets was approximately 19.5 in. Photomicrographs taken of the weld zone showed that the fusion of the weld faces was complete, with the grains crystallizing across the weld line. No oxide inclusions were evident in the weld zone.

Tension tests were made on the thinner of the two base metals and on the welds. On the base metal samples an average ultimate strength of 51,700 psi. was obtained, as compared to 62,500 psi. on the weld specimens. Average yield strengths were 34,500 psi. for the base metal and 46,300 psi. for the weld specimens. The weld test specimens broke outside the weld and in the thin sheet metal. These results indicated that the welds in the as-welded condition were stronger than the 0.039-in. sheet.

Applications

Open-butt pressure welding will have a variety of applications. Some of the uses have already been indicated, such as the joining of railroad rails and bar stock. Joining of thin sheet and strip of equal or dissimilar thicknesses also have been mentioned. Interest in the process has been expressed by the oil industry for joining oil well pipes and overland piping. Other possible uses are for welding tubes and tubing assemblies, gas cylinders, and small plate and pipe structural sections.

In conclusion, it must be pointed out that the place of open-butt pressure welding process in the welding field has not as yet been completely defined. Its limitations are not as yet known, nor are its full capabilities. Only when the process has been in commercial use and under actual production line conditions for some time can a final appraisal be made. However, there is no doubt that process will have definite applications and the months to come will see continued development of its possibilities.

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Cuke, N. H. "Multiple Flame Pressure Welding Process." American Welding Society Paper, delivered before the annual meeting, Oct. 20-24, 1947.

MATERIALS & METHODS MANUAL

33

This is another in a series of Manuals on engineering materials and processing methods, published at periodic intervals as special sections in Materials & Methods. Each of them is intended to be a compressed handbook on its particular subject and to be packed with useful reference data on the characteristics of certain materials or metal forms or with essential principles, best procedures and operating data for performing specific metalworking processes.

Annual Engineering Review

by the Editors

The year 1947 saw many improvements in engineering materials and methods of processing them. Here in an easy-to-read section are discussed the most significant current developments in new materials, applications of materials, and the trends in uses of fabricated parts as well as what is new in heat treating, joining, finishing, machining and forming the various materials.

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Materials & Methods, January 1948

(Published since 1929 as Metals and Alloys)

Trends in Materials and Their Processing

By any standards it would be hard to classify 1947 as a normal year as far as engineering materials are concerned. Producers of most materials were turning out more of their products than ever before in a peacetime year. Despite high production, supplies of most materials were insufficient to meet the demand for finished automobiles, railway cars and many other goods.

Despite the still abnormal situation, the past year has given evidence which can be judged as pointing to what is to be expected in the future.

Two recent events have a profound effect on the materials picture, and a third, if it takes place, will likewise alter the present status of materials.

First, the government cancelled its bonus to marginal mines. This has and will continue to cause normally unprofitable mines to cease operations. There is some chance that such bonuses will be reinstated, but if they are the metals that become available will probably be earmarked for government stockpiles.

Second, the reduction or elimination of import duties on several metals has helped the supply picture somewhat and has reduced the price on some alloying elements. The copper tariff is now reduced to 2¢ rather than 4¢. When the import duty on nickel was removed, the International Nickel Co. immediately reduced the price of nickel by the same amount. On some highly alloyed steels this should result in a price reduction, or at least offset suggested price increases.

A possibility is the invigorating of the government's stockpiling program. If and when such a program goes into effect, some of the scarce materials will become even more scarce. Tin, chromium, tungsten, lead and other materials of this type are certain to be restricted. Even aluminum will become tighter, for the government is being urged to stockpile ingot aluminum rather than bauxite.

Raw material scarcities will tend to restrict whatever gains might be made in providing steel mill capacity. Even if capacity of steel producers is extended by 3,000,000 tons yearly, the net gain to industrial consumers will probably be less than 1,000,000 tons since we do not now have enough pig iron and scrap to meet current demands.

Too, if the European Recovery Plan (Marshall plan) is as large as expected, there will be many other spot scarcities to plague manufacturers. Planners say that exports will be no larger than in 1947 under the plan, but steel for fabrication and steel and iron in machinery is badly needed. You can draw your own conclusions.

Aluminum in the Forefront

Skeptics who were prone to class aluminum as a substitute material for all but a few applications now realize that this light metal is finding a permanent place for itself. Immediately after the war—due to the vastly increased capacity—aluminum was expected to be a drug on the market. It was. Then aluminum began to find unsuspected uses. Where the major tonnage of aluminum once went into transportation equipment, the biggest current market for aluminum is in the building field, for roofing, siding, window frames, electrical wiring and many other uses. Now delivery of some forms of aluminum is falling far behind demand.

The automotive industry looked down its collective nose at aluminum for all but a few specialized applications. Now some makers are to use vast quantities of the light metal. It would be expected that Kaiser-Fraser would use this material what with Henry Kaiser's aluminum interests. However, Ford recently announced that in 1948 it expected to use 100 lb. of aluminum per car in running boards, head lamp assembly and other parts. The net result is a 200-lb. reduction in weight of Ford cars and an estimated increase in production of 100,000 cars. The aluminum industry estimates that the 1948 potential in the automotive industry alone will be close to 300,000,000 lb.

In 1948 we shall see aluminum widely used in many other places such as beer cans, light bulb bases and pipelines.

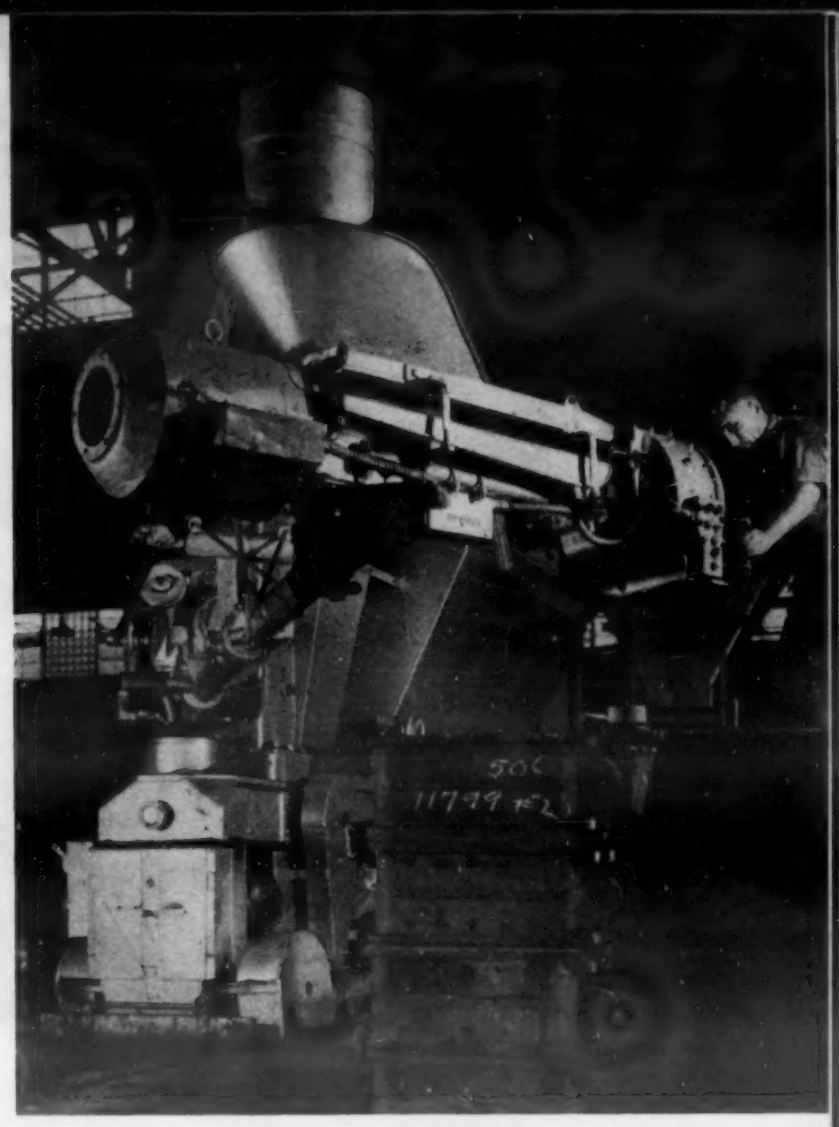
The picture in the other light metal field is somewhat different. Magnesium consumption reached a low point during 1947 when it was being used at a rate of only 1,500,000 lb. monthly. By mid-1948 consumption is expected to exceed 4,000,000 lb. monthly. Although many industries became familiar with magnesium during the war years, they failed in most cases to reapply their knowledge to peacetime products. Scarcities of other metals will drive some product manufacturers to magnesium. Other users will accept it because of its exclusive properties. Regardless of the reason for accepting magnesium now, many users will continue with it when they learn more about its processing.

Although availability in many cases is more important today than price, the reverse situation will be with us before too long. When that time comes the price advantage of aluminum and magnesium on a per pound basis will help them keep markets and perhaps gain others.

What About Steel?

The steel situation does not yet give any indication of clearing—at least not in the near future. Although new capacity is being rushed into being, most of it will be too late to do any good in 1948. Perhaps another price increase on steel, which is being advocated in many quarters, will check the demand somewhat, but probably not enough to have any great effect.

A trend which gathered strength during 1947 will probably continue even stronger henceforth. That is the use of specialty steels which permit use of less expensive materials or which permit the use of less steel for many types of applications.



An increasing recognition of the properties of cast iron has resulted in a new appreciation of this engineering material. Foundries have helped increase output by bettering working conditions and installing high production equipment such as this sandslinger in the new Elyria, Ohio, foundry of Electro-Alloys Div., American Brake Shoe Co.

High-strength, low-alloy steels have, in the past, been used rather generously in railway freight cars and some passenger cars. Their use on these products has increased and will continue to increase. The greatest increase will come in other fields, however. Some automobile builders have accepted the high-strength steels for body parts and will probably continue to do so. Manufacturers of such equipment as tractors and earth-moving machinery are replacing ordinary steels with high-strength steels and gaining working capacity by lessening dead weight. On a cost per ton basis this type of steel is somewhat more expensive than the steels they replace. However, in many instances three tons of the high-strength steel will result in products which would have required four tons of the former material.

Clad steels will be used even more widely now that they have become available with claddings of many of the major types of stainless as well as the nickel, Monel and Inconel claddings formerly used almost exclusively. Many more companies are interesting themselves in clad steels, a certain sign that users themselves are seeking more of such materials.

Despite the vastly increased uses of aluminum and magnesium and the replacement of metals with plastics, there seems little chance that steel will be unseated as our major engineering material. More of each of many types of products made principally of metals are being consumed now than ever before. Thus, all metals are profiting.

After a temporary shift in interest away from cast iron, many consumers are again turning to this metal form.

Much of the replacement of castings with other metal forms was due to difficulty in getting castings. Three things contributed to this situation: shortage of iron and scrap, labor leaving the foundry for more pleasant working conditions, and, a period when cast iron could not offer sufficiently high physical properties.

At present all of the factors are being overcome, with the possible exception of the shortage of raw materials. Foundries have modernized and are selling themselves as clean, healthy and pleasant places to work. Cast irons are now available with excellent properties. Castings now being made develop over 60,000 psi. tensile strength, with some special alloy gray irons reaching almost 100,000 psi. Proper design of castings through stress analysis has helped to reduce unnecessary weight and bulk, overcoming another objection to castings.

Domestic production of copper during 1947 was approximately 1,000,000 tons, which compares with consumption of 1,400,000 tons. The extra 400,000 tons was imported to set a new record in this department. Some economists predicted a year ago that this country would never again see the 1,000,000 ton mark hit. Perhaps that will be true in 1948, for we keep hearing that the best of currently operating mines are running low on high grade copper ores.

Copper has not been exceedingly tight in recent months, but this is probably true to other materials taking its place. Aluminum, for instance, has taken over a large share of the electrical wiring field. With more and better plated products in demand, there is an additional draw on copper output, since a base coating of copper is used under most electroplated surfaces.

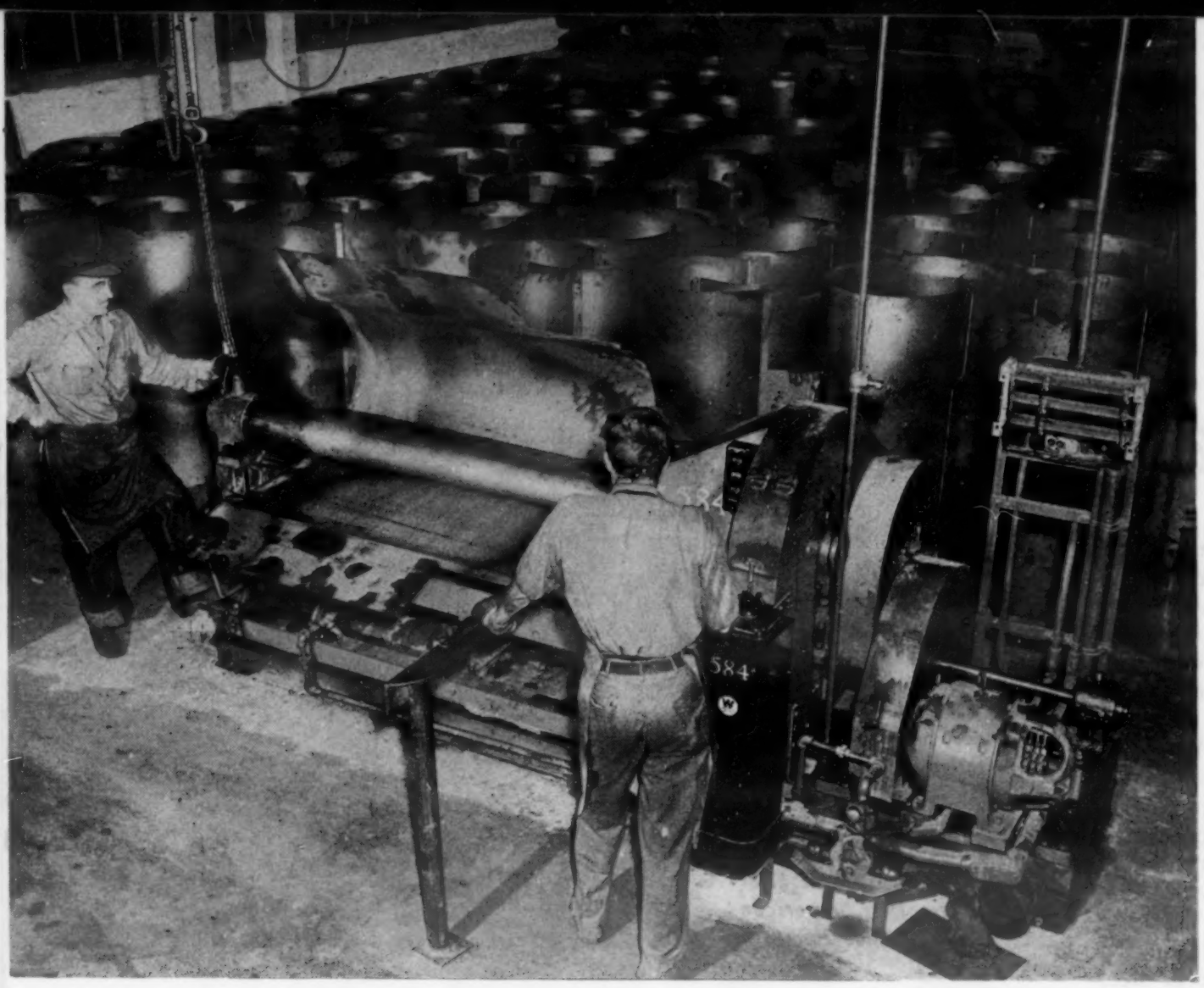
Nonmetallic Materials

The plastics industry has been through what it hopes is its postwar slump. Starting in the late spring of 1947, many molders and fabricators were digging hard for business. The industry generally has pulled itself up from its low point and now many shops are working at top capacity.

Much of the slump probably can be credited to a materials reevaluation on the part of producers of plastic parts. Even at this late date some fly-by-night concerns misapply plastics. When the products they sell prove unsuitable, the entire industry suffers. This situation is being fought both by plastic materials manufacturers and the fabricators. As one fabricator states in its slogan, everybody in the basic plastic industries are selling "plastics where plastics belong."

Some raw plastics materials as well as plastic sheets, rods and tubes of certain types are coming down in prices. This trend is helped by the fact that some materials supplies are catching up with demand—a situation which did not exist last year at this time.

During the last 12 months we saw rubber imports keep rising until now



Part of the shortage in sheet steel is due to its increased use in household equipment. Here sheet steel is being rolled into furnace bodies.

we have more than enough natural rubber to meet our needs. Because of the general availability of natural rubber, many users of synthetic rubbers are abandoning that material. Such a situation is bad for all concerned, for in certain cases the synthetic material is better than natural rubber. Too, we as a country need the synthetic rubber capacity we have built up.

As a result, the government is likely to demand that large users of rubber continue using certain percentages of synthetics.

Generally, it is to be expected that rubber prices will be held down. The prices will hold because of the generous supply, and because plastics are now being used for products once requiring rubber, such as raincoats. Most of the older rubber companies are now also producing elastomers.

Trends in Processing

Since there is little they can do in regard to the prices of engineering materials, manufacturers are turning to their processing methods to reduce final costs of their products.

There has been little that is startlingly new in means of heat treating, machining, welding or finishing during the last year. But in most of these fields there is a decided trend towards the use of automatic equipment. And, automatic equipment is being so designed that it does not require an engineering education to set up or operate.

To one attending the Machine Tool Show in Chicago last September, the truth of the above statements is evident. There one could see lathe after lathe equipped to follow complicated contours automatically. Gear generating machines require only that the operator insert the workpiece and press a button. Countless pieces of duplicating equipment were to be seen ranging from the huge Keller machines down to tiny Gorton 3-dimensional engraving machines.

Many tool manufacturers showed machines specifically designed to take advantage of the speeds and feeds possible with carbide tools. This is particularly true of milling machines.

In the field of heat treatment, we saw little that was basically new last year. But here, too, there is a continuation of the trend towards mechanization. One of the newest pieces of heat treating equipment is an automatic flame hardening machine introduced by Cincinnati Milling Machine Co. This electronically controlled machine makes possible the flame hardening of rotational parts at speeds comparable to any other heating method.

The carbon restoration process introduced during the war has started to take a hold on peacetime products. Parts of low carbon can be completely formed and then subjected to this treatment and given the most desirable hardness and wear characteristics. This phase of carbon restoration is an extension of the earlier processes whereby steel which has become decarburized during working can be brought up to standard. The method is known in some quarters as skin recovery.

The same trend toward automatic operation is in evidence in metal joining. Submerged-arc welding processes are now being adapted to smaller parts made of thinner gage metals than formerly. Some equipment is made so the welding head can be moved wherever necessary on the work; in others the head can be made to follow contours and go around corners.

All of these steps mean that less time is spent handling the products being processed, thus increasing productivity and offsetting, somewhat, constantly rising labor costs.

Trends in Testing

The last year has seen a noticeable increase in the use of simulated service tests as well as the use of full-scale test specimens. Results obtained indi-

cate that this type of testing will continue more strongly as an adjunct of normal testing and inspection procedures.

There is a definite reason for these two testing methods coming to the fore. Serious failures in the field has thrown some doubt on the complete reliability of standard shop and laboratory tests. Here are a few examples: Ship plate failures, aircraft failures in flight tests and actual service, and pressure vessel failures. Engineers are now reluctant to accept correlations between tests on small specimens and performance of the same material in large structures. The practice evolving is to have full scale tests first and then determine whether small specimen tests correlate with full scale test results.

An advance in knowledge during this period has occurred during the past year on the differences in performance of laboratory test specimens and actual size test pieces. For instance, it has been shown that elastic strength developed by full scale plate specimens and joints is less than in laboratory specimens. A small specimen deforms uni-axially while a wide plate deforms bi-axially. Also, in determining the transition between ductile and brittle failure at low temperatures, it has been found that wide plates may lose ductility faster than smaller test specimens. An example is a large pressure vessel lined with high-nickel steel. This vessel for holding gas failed at a very low temperature even though the steel performed quite satisfactorily under regular impact testing methods.

A continuing search goes on for small-specimen tests which will correlate with performance of the material under actual service conditions. These are some of the tests being investigated: a slow notched-bend test with relief on the compression side; a test in which a reduced-width plate is notched in the center and pulled; a tear test in which plate is notched on the edge and then pulled in tension.

High Temperature Testing

The problem of finding new and better means of testing high temperature alloys continues to be a major task. No really new methods have been developed within the past twelve months, but refinements in technique, procedure and equipment were made. In creep testing, studies were made using a controlled atmosphere around the specimen; ceramic grips for the test specimen were adopted in one laboratory and showed good high temperature hardness and stiffness. A new type of stress-rupture testing machine was developed to carry through the creep tests to rupture more rapidly.

In relaxation testing, special machines have been developed to simplify the testing. One of these has a stress-time recorder mounted integrally on a unit frame.

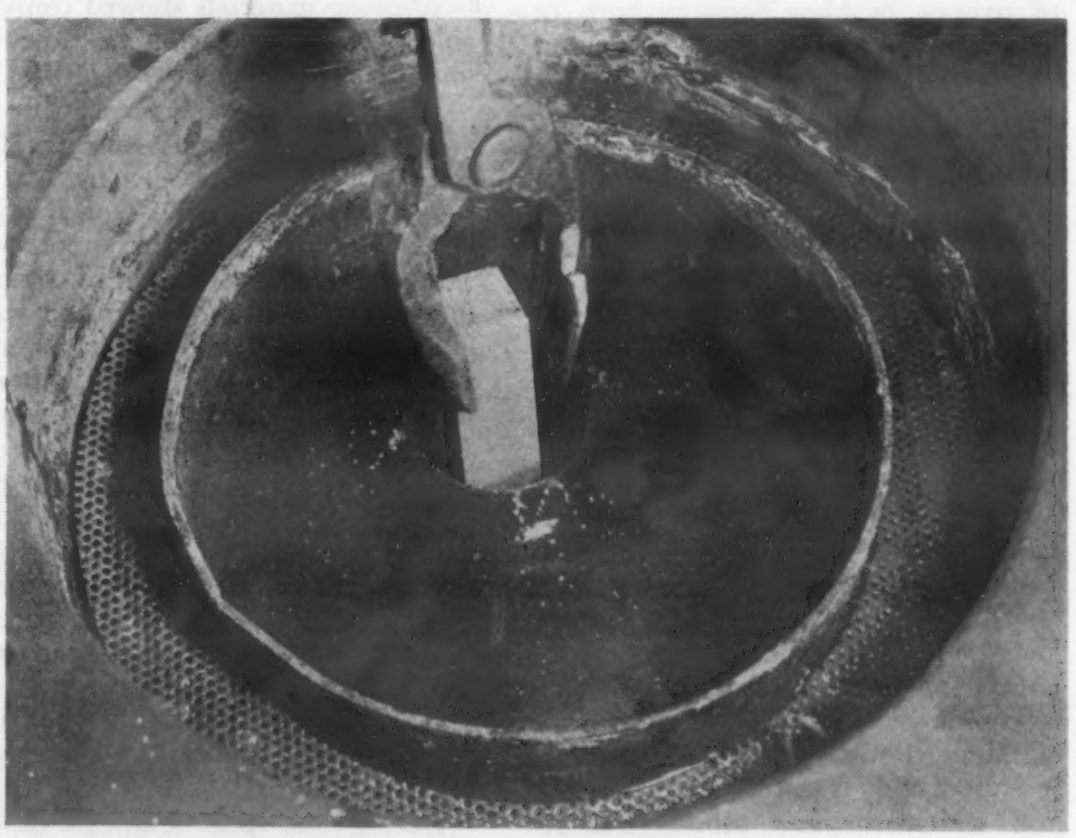
Simulated service testing has also been resorted to for testing high temperature materials going into gas turbine wheels. Disks of the high-temp materials are tested to destruction in specially designed equipment. The pieces are heated to temperatures of 1200 F or higher and then spun at the rate of 35,000 rpm. (1200 mph.) until the disks fly apart. By these destructive tests, researchers hope to determine the ultimate strength of the alloys and study the behavior of the metal under actual service conditions of both stress and temperature.

Product and Parts Inspection

Detection of cracks on or near the interior surfaces of hollow parts, such as tubes and cylinders of various kinds, is difficult by regular magnetic particle inspection methods. Inaccessibility of the surfaces has been the big problem. A new flaw detector substitutes an electro-magnetic pickup coil for the magnetic particles used in the Magnaflux method and overcomes the difficulty.

The steel tube or cylinder to be tested is magnetized. If any flaws are present there will be magnetic leakage at those points. Since the electromagnetic coil is sensitive to any magnetic leakage, the flaws are readily detected. The pickup coil is connected to an electrical indicator or recorder to either signal the presence of a flaw or supply a permanent record of its location. The instrument can also be used on flat surfaces. Surface cracks as shallow as 0.05 in. have been detected. The instrument was developed at Watertown Arsenal.

A new surface roughness measuring instrument was developed in England by David Brown Tool Co. It is called the "Topograph" and is capable of measuring surface irregularities down to 2 microinches. The device operates on a simple pneumatic principle and provides a pen recording of the surface profile along a straight line on the material's surface. A jet of air from a 0.046-in. dia. orifice is intercepted in varying degrees by movement of a



While quenching is ancient as far as steel treatment goes, research continues to learn just how quenching affects the metal. This U. S. Steel Corp. research photo taken with an exposure of 1/10,000 sec. shows how white-hot steel actually punches a hole in quench water. The void is really filled with water vapor.

tracer point over the surface. Surface roughness causes a variation in air pressure at the orifice, which is relayed to a pen recorder. The tracer movement can be magnified 20,000 times. The instrument is normally used on flat surfaces, but can be used on curved surfaces that have a straight line along which the tracer can travel.

Instrumentation and Control

In the field of instrumentation and control, the trend continues in the direction of completely automatic process control. The tendency is for the control equipment to be tailor-made or adapted to meet the specific needs of each installation.

As would be expected, producers of indicating, recording and control instruments announced many refinements during 1947. Most improvements provided greater sensitivity and accuracy, others improved the construction, convenience as well as operating characteristics of the instruments.

Irons and Steels

One would think that with a group of materials as old and as well known as the irons and steels that there would be little room for improvement in either the materials themselves or in their application. Such is not the case. The year 1947 has seen its share of newness as regards iron and steel.

As a matter of fact, the past year has seen improvements in methods of producing steel, forming it, finishing it and protecting it in service.

The attention of most steelmakers has been focussed on the problem of extending the availability of finished steel products. In addition to building additional capacity, producers have looked for means of increasing the output of present furnaces and rolling equipment. One of the most important steps in this direction is in the use of oxygen in blast furnaces both to speed up the melting processes and to improve the quality of the finished product.

During the year much was heard of some new processes of making segregation-free alloys. One of these, developed by the Latrobe Electric Steel Co., results in a product known as desegatized steel. Improved properties are claimed for the tool steels so produced due to the complete homogeneity of the alloying constituents. A second process, developed by the M. W. Kellog Co., is expected to be applied to all types of alloys, including stainless steels. By the latter process, a basic carbon steel is melted in an electric furnace together with the alloying elements, which are added in powder form. As melting and alloying is completed, the solidified ingot is withdrawn from the high heat area. It is too early yet to determine just how widely the new process will be adopted, but it is expected that it will be applied to the problem of producing the successors to the current family of so-called super-alloys.

New Materials

Most of the new materials announced during the last 12 months were in the field of tools steels.

One of these is a high-speed steel being produced by Vanadium-Alloys Steel Co. Termed Vasco Supreme, the material is intended for cutting materials of high hardness. Its additional qualities include high hot-hardness, hardness after heat treatment and resistance to wear. If necessary, Vasco Supreme can be used at hardnesses of greater than Rockwell 66 C. This tool steel has a carbon content of 1.50%, 5% vanadium and cobalt. Tests of the new tool material on such other materials as SAE 4340, cast alloy steels, high carbon, high chromium tool steels, hard cast irons and other hard-to-machine materials showed considerable savings in machining time and increased tool life between grinds.

The Amalgamated Steel Corp. is now producing a steel—know as Tool Room Specialty Steel—which is designed for perhaps 80% of the jobs encountered in the ordinary tool room. This alloy tool steel is said to combine the best features of oil, air and water hardening steels. Indeed, this new steel can be quenched in oil, water or salt bath and provided with almost any degree of hardness. High resistance to wear, toughnesss and strength plus ductility are claimed for Tool Room Specialty Steel after more than a year of experimentation and testing under actual service conditions. The material is said not to crack during heat treatment, to weld readily, forge well and provide an excellent finish when machined. It is available in all the usual tool steel shapes.

During the year Carnegie-Illinois Steel Corp. announced a new series of four steels under the name SuperKore. These carburizing steels are deep hardening and are less costly than the more highly alloyed carburizing steels. Their makers intend the SuperKores for material and manufacturing economy in producing such parts as gears, shafts and pinions intended for heavy-duty service. Although full details of this new group of steels have not been publicly announced, Carnegie-Illinois claims for them good machinability, carburizing characteristics and annealing facility.

An increase in the utilization of clad steels has led to new types of these materials being introduced. One of these is a silver-clad steel produced by a new process. Another is a double clad stainless steel-copper combination designed for such use as cooking utensils. One roller is now producing a clad strip steel which is available in extremely thin gages. As-rolled thicknesses range from 0.010 to ¼ in. and rerolling can take the thickness down to 0.002 in. The thin clad is being used for conveyor belts, measuring gages, fan blades, instrument dials and the like.

An interesting development in cast iron is the production of an austenitic malleable iron. This development comes from the American Cast Iron Pipe Co. The material has good mechanical properties, machines well and is high in corrosion resistance. So far the material is being used most extensively in corrosion resistant cast bolts for pipe joints. Compositionally, it is a modified Type I Ni Resist cast iron. In the processing, the composition is given a malleable rather than a gray iron structure. The material has a tensile strength of about 70,000 psi., yield strength of approximately 50,000 psi., and a Brinell hardness of between 180 and 200.

Another new cast iron is first described in this issue (page 79). The material developed by the Piston Ring Div. of Koppers Co., Inc., was in answer for the need of piston rings

which would permit greater output in automobile engines. The desire was for a castable material which would have better physical properties than those of individually cast gray iron piston rings.

The material's composition differs from that of a standard in that it contains less of all the alloying elements except manganese. In addition it contains copper, 0.55, and molybdenum, 0.50%. The material is centrifugally cast and solidifies as white iron and is thin heat treated.

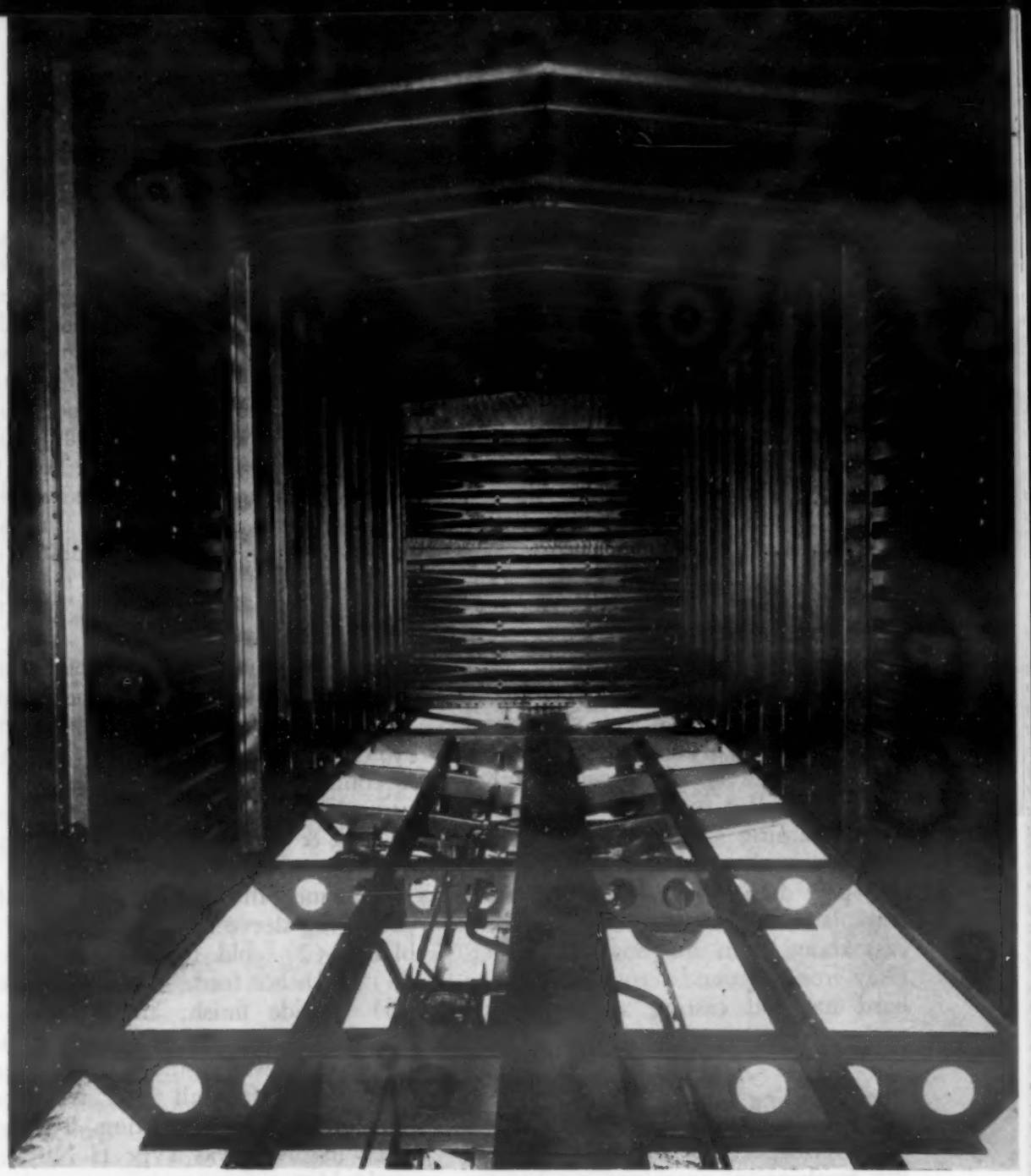
This fine grained material provides tensile strength on the order of 95,500 psi. and a Rockwell C hardness of 26. It is fine grained and can be used for piston rings in most types of engines except those powered by steam and natural gas. For the latter applications an open-grained material is more desirable.

A new development in materials for powder metal parts is the introduction of stainless steel powders. One of the most important uses of powder metal parts made of stainless steel is in fabricating filters for use with highly corrosive materials. Stainless powder is also available in flake and paste form for making paints intended for surfaces likely to be subjected to highly corrosive conditions.

Iron and Steel Applications

The general scarcity of steel has led to a general sharpening up of selection processes. Some of the applications of ferrous materials which now come under the guise of substitutions are destined to become permanent for it has been found that the materials considered as temporary are better and more economical than the materials replaced.

During the last year there has been a great increase in the use of both clad steels and the high-strength, low-alloy steels. These steels as classes are not new, but until recently their application has been somewhat restricted and often confined to a few specific industries. For instance, the high-strength steels have been used for many years in the fields of heavy transportation for such products as freight cars, mine cars, truck trailers and the like. Recently they have been adopted more generally by the automotive industry for passenger car bodies and fenders. They are being applied more broadly to such things as bridges, superstructures on steamships, dam and canal parts and many other things where lightness is an advantage, resistance to corrosion helpful and long life an extra value.



High-strength, low-alloy steels are helping to reduce the dead weight of railway freight cars. In addition to giving longer car life, these steels permit a greater revenue pay load. Those parts visible in this illustration are of high-strength steel.

The uses of clad steels were once confined primarily to the process industries where materials had to have strength, workability and, above all, the ability to handle corrosive media. Now there are available many types of clad steels. During 1947 there was a great increase in capacity for production of mild steel clad with the most common grades of stainless steel. Manufacturers of such automotive parts as bumpers, bumper guards and body trim are using the clad steels in increasing quantities. The advantage in such materials is that even though a plated coating may flake or be chipped off, the exposed surface will not rust since it is of stainless steel. The stainless, of course, will last as long as the bumper, or other part, itself.

An additional drain on the supply of deep drawing steel is the increasing use of this material for bathtubs and other kitchen and bathroom equipment. Other producers have entered this field, and now production of such fixtures represents a healthy percentage of stamped and drawn products now being turned out.

Cast iron returned to favor in many quarters during the last year. If only the raw materials situation were better, probably more iron castings than ever would have been used. Vastly improved foundry working conditions have helped recruit workers for the foundries. Better physical properties have permitted castings to be used where they had been considered inferior. Finally, thinner sections and a general reduction in casting weight resulting from enlightened design and stress analysis overcame another objection.

One other market seems to be slipping away from cast iron, however,

and that is in end-bells and housings for large electric motors. Westinghouse, during the year, opened its new motor division plant and showed its method of producing such parts from stamped and rolled steel plate. Automatic welding joins the stamped parts where necessary. This replacement among other design changes permits a substantial weight reduction in any size of motor for its rated output.

In England a bimetal casting was introduced for the camshaft in a four-cylinder automobile engine. The part is not entirely new, but has been in production since shortly after the war's end. The camshaft contains a center portion which is used as a distributor gear. Since gray iron would not supply the desired wear properties, another alloy was called for. A low carbon alloy containing silicon and chromium was cast in the desired internal shape. The part then served as an insert and was placed in the mold and gray iron cast about it in the normal manner. Gray iron surrounds cross bars in the hard material casting and is firmly anchored in place.

Heat Treating Processes

In retrospect, no advances made in the working of iron and steel seem startling. However, several significant steps were taken which help users of iron and steel process these materials faster, better and more economically.

Most development came in heat treating and allied processes.

At the Metal Show in October the Cincinnati Milling Machine Co. showed for the first time its electronically controlled automatic flame hardening machine. Known as the Flamatic, the new machine heats the parts rapidly to proper temperature and then drops them in a quench tank. The control is said to be so accurate as to put the parts in the quenching medium at a point when their temperature is within 5 F of the desired value. The machine is most useful on rotational parts such as gears, shafts, cams, pinions and similar components.

The machine is completely automatic except for loading. Since depth of penetration of heating can be controlled accurately, parts hardened in the machine can be processed without affecting core properties.

Earlier in the year Surface Combustion Corp. described a new set-up for suspending carburization of parts left in a furnace for extended periods. The advantage of being able to do this is obvious when it is realized that up to 24 hr. can be lost in resuming production on continuous gas carburizing furnaces after a weekend shut down. Such an operation involves a four-zone furnace: the first two for heating and carburizing, the third for cooling, and the fourth for reheating. Methods for suspending carburization involve precise control over the heating areas and the atmospheres used. A complete description of the process is to be found in the February 1947 issue of MATERIALS & METHODS.

During the last year details were revealed about a method whereby nitrided steel parts can be hot formed after heat treatment. Such a procedure is contrary to all of the rules, but it proved highly satisfactory in the plant of Jack & Heintz Precision Industries. The process was developed when it was learned that a desirable cycle for producing sleeve valves would be: (1) blank; (2) cold form; (3) nitride; (4) finish hot form; (5) inside hone; (6) outside finish; and (7) finish condition. The advantage lies in the fact that sleeves would be given their final form after all heat treatment, thus eliminating distortion. The material involved was Type H Nitralloy steel. However, previous experience advised against heating the material after it had been heat treated.

The solution came through a combined forming and pressure quenching operation. The trick which made the process work was the complete control of the rate of heat withdrawal from the work. A water cooled die was used. It was of such a design that hot metal would not come in contact with the cold die until actual forming was started. Temperature, cooling rate and die pressure during forming are all critical.

The success of the forming procedure can be judged from the fact that during a run of several thousand production valves only 2% of the pieces varied noticeably from the nominal dimensions.

Forming Steels

During the war zinc alloy die materials were used to form sheet aluminum into aircraft parts. Tremendous savings in die costs were possible through the use of such materials. It was natural that producers of drawn steel parts should attempt to use zinc die materials in their power presses to produce such parts as automobile bodies. Zinc alloy die materials proved highly satisfactory with steel and provided a means of producing, through drawing, shapes that formerly were hand made, since quantities were not sufficient to justify steel or cast iron dies.

Zinc alloy dies are not used to compete with usual die materials, but serve in those cases where a few hundred parts are desired. In some instances 500 to 600 parts have been made from the dies without noticeable die wear in steels as heavy as 20 gage and 5/32 in. The use of steel inserts in the dies at points where greatest wear is expected can extend die life to the point where several thousand parts could be produced.

In addition to permitting dies to be finished in a matter of hours after the pattern is ready, Kirksite dies offer the extra advantage that the die material can be melted and recast into other die shapes. Losses in die material should not exceed 5% in each melting.

Kirksite die materials, in the alloys used for this purpose, develop tensile strengths of about 37,000 psi. and have a Brinell hardness of about 100 under normal cooling and 130 if the casting is cold quenched after it is set but still hot.

Still another step forward in making dies for the production of small quantities of drawn parts has been developed at Ford Motor Co. research laboratories. An alloy of bismuth, tin and lead is formed into the desired die shape, then frozen in liquid nitrogen. While the die is still extremely hard it can be used to turn out 6 to 20 parts and then is returned to be refrozen if more parts are desired.

From another automotive plant comes a method of using bar stock to make blanks for starter ring gears. Studebaker uses 20-ft. long bars of SAE 1042 hot rolled steel as the raw material. The bars are rolled into spirals of six turns; the spiral is sawed through one side, making 6 near-circles; ends of the cut-off pieces are butt-welded to form the gear blanks. The blanks are hobbed to form the gears and then inductively hardened to provide wear resistant teeth and leave a relatively soft core.

One manufacturer of aircraft parts described the method of producing aircraft engine cylinder liners made of austempered alloy cast iron. Hardened liners have been used successfully

in internal combustion engines for a number of years, especially in heavy-duty bus and truck engines. The superior wearing qualities of the liner surfaces when hardened improved the life of piston rings and pistons. A growth in use of hardened cast iron liners is expected since many manufacturers are considering the use of other materials for their engine blocks.

What is new is the use of austempering to: minimize distortion; obtain a uniformly hard liner free from high stresses; and, avoid surface decarburization. By salt bath treatment, the company saved almost half the labor time and over half the finishing stock required for former heat treating methods. Average distortion by the austempering method is between 0.003 and 0.004 in., as compared to between 0.010 and 0.020 by former methods.

Welding and Cutting

During the last year, development in joining and cutting ferrous metals was concentrated largely in the high alloy groups. This is natural, since these materials have been difficult to handle and to industry present a much greater problem than do the mild carbon steels.

The use of submerged-melt arc welding on nickel-clad steels is now successful. Development of a satisfactory method is valuable, since clad steels, generally, are being much more widely used. By this method, a manually-laid bead is placed in the Vee extending through the cladding material and into the mild steel backing. Next, the groove is filled through the automatic welding process. Finally, the opposite, or mild-steel, side is welded.

The newest developments center about the cutting of alloys. There were two basically different methods introduced during 1947.

The Arcos Corp. sponsors what is known as the Oxyarc process. In this method a coated tubular electrode is used. Through the hollow center of the electrode a stream of oxygen passes. The oxygen strikes the work in the center of the arc and helps greatly in the cutting action. Type 347 stainless steel, ¼-in. thick, can be cut at a rate of 10 in. per min., at a total cost of about 15¢ per ft.

A second new cutting method is that introduced by Linde Air Products. By this process, iron-rich powders are injected into the stream of cutting oxygen. The refractory oxides which form are removed by a combined melting and fluxing action.

Nonferrous Metals

During 1947 most of the activity in nonferrous metals centered about the light metals. With aluminum's rivals often becoming scarce and high priced, the light metal remained stable, even reduced in price in some instances, so it was natural for aluminum to forge ahead. It forged ahead so fast, in fact, that users are experiencing delays in getting aluminum in certain forms.

Aluminum Field Active

A new aluminum casting alloy D 132, as reported by Alcoa, offers greatly improved casting characteristics, improving piston castings. It has a low coefficient of thermal expansion. For aluminum alloy piano plates the casting process switched from sand to permanent molds. Cast aluminum electric motor rotors and end bells were more widely used in 1947.

"Alclad 35," resistant to localized attack, was first marketed in 1947. It has a central core of No. 35 with No. 725 on both sides. Thus, the core will not be attacked until all coating for a considerable area is removed, the coating being anodic to the core. American Airlines found fuel tanks of No. 35 had a life of 3000 flying hours; Alclad 35, however, had 15,000 hr. It is also suitable for condenser tubes.

Reynolds Metals Co. brought out a new aluminum "utility sheet" during the year, specially alloyed for increased strength and resistance to chemical attack. It is devised for a wide range of products including air ducts and building products such as flashing, valley material, ridge rolls, portable sheds, containers and enclosures. It takes a Pittsburgh lock seam, is easily bent, formed, welded, and otherwise fabricated.

Alcoa also announced its industrial roofing and siding, a sheet highly resistant to corrosion. It is supplied in Alclad form to minimize the possibility of local failure under severely corrosive conditions. Its strength meets building code requirements using purlin spacings and methods of attachment commonly used with metal building sheets. An aluminum alloy sheet for bearings is now on the market. Alcoa has developed an improved brazing sheet, with lower melting point, hence greater spread between parent metal and brazing sheet, simplifying brazing.

During 1947 the United States Gypsum Co. came out with expanded metals of both aluminum alloys and 18:8 stainless steel. The new products open possibilities in expanded metals exposed to moisture or corrosion, or where extra light weight is a factor, such as baskets, drying trays, conveyors, fan grills, refrigerator shelves, toasters, broilers, etc.

Reynolds also introduced R-317-T, a strong aluminum alloy as a free-machining screw machine stock, available in all standard sizes of rounds or hexagonal.

Aluminum anodes for electrolytic corrosion protection of pipe lines and other buried steel structures are now supplied in "packaged" form with the chemicals needed to assist the galvanic action cast in a rigid form around the electrode.

More was learned during the year of the newer European aluminum alloys. The French brought out Zicral, or A-Z8-GU, having better corrosion resistance, containing: zinc, 7.0 to 8.5; magnesium, 1.75 to 3.00; copper, 1.00 to 2.00; chromium, 1.00 to 4.00; manganese, 1.00 to 0.60; iron, 0.7. It was reported from Germany how small additions of lead to an aluminum alloy, with 8% magnesium, improves properties, including machinability. A maximum of 3% lead can be alloyed, there being no segregation of lead up to 2.5%. Reported, too, was a surface hardening method for aluminum, the surface being enriched with copper.

Revealing progress during the year was the appearance of a new 16-page booklet on new temper designations for Alcoa alloys, effective Jan. 1, 1948, set up because metallurgical advances and improved fabricating techniques made the existing system inadequate.

One of the accomplishments of the year by the aluminum manufacturers was the convincing of a host of skeptics of the economies in use of aluminum.

Metal-wood composites are another approach to obtaining high strength with low weight. Here in Chance Vought Aircraft plant Metalite panels are placed in an autoclave where the aluminum alloy face plates and balsa wood core are bonded together under moderate heat and pressure.

A typical case is for aluminum automobile license plates. By the use of the newly developed embossed sheet, one can provide aluminum 0.025 in. thick, having the same rigidity as a sheet of steel of the same thickness. An analysis for California shows that 5,000,000 sets of such license plates could be produced and delivered at less cost than steel plates since it is not necessary to paint the background or the back side of the plates, saving 2½¢ per plate on painting. The postage for mailing the plates was about half that of steel plates. The result was that the steel plates cost *more* than the aluminum.

The high cost of aluminum "bugaboo" was largely dispelled as regards ductwork during 1947, it now being recognized as a duct material of outstanding value. A bright future for aluminum and stainless steel development in valves for use in chemical plants is foreseen.

There has been a greatly increased acceptance of extruded aluminum tubing for portable irrigation systems; also expansion in use of extruded pipe for gathering and distribution lines in oil fields. Gaining fast are aluminum alloy wheels, cast and forged, for buses and trucks. Forged pistons are being produced for heavy-duty trucks and Diesel engines.

Progress in Magnesium

Extruded magnesium-base alloys containing zinc and zirconium have now been placed on limited commercial sale, it was announced near the close of the year. The 5.5 zinc and 0.6% zirconium alloy (ASTM designation ZK60) develops, with suitable processing technique, including aging, higher compression yield strengths than have been heretofore available in magnesium-base alloys. It has a toughness comparable to some of the older, lower strength alloys and can be extruded at similar speed rates. It will have considerable use in stressed construction, particularly airframes. Service experience in several commercial applications have been gained over the past two years, hence has gone through a reasonable testing period.

Cast and wrought magnesium-base alloys containing cerium are being sold, as yet, only on an experimental basis. American practice differs from the German in that castings, forgings and extrusions are being tried, all being given a solution heat treatment and age, which provides a definite improvement in several properties, particularly the creep resistance of the wrought alloys at higher temperatures. The magnesium-cerium alloys may eventually extend the temperature range of magnesium alloys by as much as 300 F.

Magnesium strip coils, said to offer an advantage in fabrication by enabling mass production in strip fed form over individual sheet feeding, are announced the past year by Burgess Battery Co. The "thinstrip" magnesium is available in coil strip form in widths from ¾ to 5 in. and in gages from 0.010 in. down to 0.005 in.

At the December chemical show the Aluminum Co. of America displayed its new aluminum and magnesium anodes for cathodic protection of pipelines and buried structures endangered by corrosion through electrolysis.

Copper and Its Alloys

One of the new important alloys, with copper the major element, is aluminum bronze 712, promoted by the Bridgeport Brass Co., and not yet generally announced. It is a spring strip alloy with composition: copper, 95.0; aluminum, 3.5; and silicon, 1.0%. Its cold working properties are described as excellent; its hot working, good. It has excellent physical fatigue and corrosion properties.

Also new, to this country at least, is a British alloy, a free-cutting nickel phosphide bronze which is now being developed by an American brass maker. It is designed to be used extensively for forgings and screw machine parts. A feature is that it is an outlet for what is usually a drug on the market—phosphorus-bearing copper scrap.

The Beryllium Corp. has announced a few new beryllium copper alloys during the year and revised others of longer history. Three are new: Berylco 1655, which is a lower cost heat-treatable beryllium copper alloy of 1.7 beryllium content meeting physical standards set by ASTM for the 2% alloy; Berylco 165 ST, a mill-hardened beryllium-copper alloy requiring no heat treatment by the fabricator and combining formability and strength as hardened by the mill; Berylco 25S, the high performance 2% beryllium-copper alloy having exceptional formability as supplied and heat-treatable to the highest strength and hardness of any copper alloy.

Revere Copper & Brass, Inc. brought out a new low nickel condenser tube that resists erosion and corrosion comparably with the more expensive 70-30 cupro-nickel tubes. These new tubes contain 5 to 10% nickel and 0.75 to 1.50% iron.

New Lead Applications

Though lead has lost certain outlets in recent years, such as in the use of aluminum foil rather than lead foil, it has gained in other fields. First to come to mind is its new use in protecting life against products of nuclear fission. During the year special designs of interlocking lead bricks for the erection of movable barriers to rays were developed; also, special types of containers for transporting radioactive materials. There were also devised various methods of combining the low cost of concrete barriers with the space and weight saving of lead barriers for large immobile installations, even to the extent of investigating the possibilities of combining lead concentrates or lead minerals in the concrete aggregate.

The U. S. Forest Products Laboratory has developed a method of dimensionally stabilizing dry wood by immersing the wood in a low melting lead alloy bath. A new patent covers a method of flame-proofing fabric by impregnating the fabric with a silicate glass of lead. New, too, in the plumbing field are lead bends or stubs for connecting water closets to soil stacks, supplied with one end spun closed in the factory. This permits testing of the piping installation without the need of the part soldered-closed by hand on the job.

The Andrews-Knapp Construction Co., Inc. has brought out two new applications for lead, demonstrated at the Chemical Show. One is lead-covered copper heating and cooling coils, produced by volume pouring, thus cheapening prices. Another is homogeneous lead-lined chemical tanks supplied in knocked-down form, complete even to angles to insert in the corners.

Powder Metals

An aluminum powder, oxide free, is being developed and was expected to be in the pilot plant stage by Jan. 1, 1948. The project was instigated at the urging of a maker of automotive bearings.

The use of electrical contacts from metal powders are expected to increase. Thus, small circuit breakers for domestic use are made possible by sintered contact materials such as silver-molybdenum and silver-tungsten, improving contact arc and wear resistance. Two new silver-"moly" electrical contacts, with good arc resisting characteristics, are being made by Gibson Electric Co.: Gibsiloy M-10 and M-12, the latter containing more molybdenum and for use on heavy circuit breakers where greater mechanical and electrical stresses are encountered.

A new silver powder, made by Alloymet Mfg. Co., is claimed to have high purity and density, to contain no free acids nor alkalis, and to be unusually gas free. The grains are in a fully annealed condition and do not have burnished surfaces. The particles are irregular in shape, having hooks and arms, producing an interlocking effect, giving compacts of high green strength. The high density permits use of a shallower die.

A recent development is the use of sintered metal compositions for permanent magnets. By powder metallurgy, steel backed copper-lead bearings are less troublesome to make (the lead segregation being eliminated). Flow and density characteristics are high, permitting an even spreading with minimum shrinkage in sintering and rolling. Small amounts of silver or nickel may be added.

A sintered alloy, Mallory 1000, containing 90% tungsten, balance base metals, is resistant to atmospheric corrosion and to certain acids, making it useful as fixtures in electrolytic processes. It is suitable for highly stressed parts such as balancing components and rotors; also for radium containers. Unlike pure tungsten, it is readily machinable. It is made by P. R. Mallory & Co., Inc.

Among novel new equipment is a briquetting press for complex powdered metal parts which extends metal powder application to large irregular cross sections. The press, made by E. W. Bliss Co., produces parts beyond the size range and capacity of available single-action mechanical or hydraulic presses and to close tolerances.

Several industries which have not previously used pressed metal powder parts in their production are doing so after investigating the possibilities. For example, in the clock industry, gears, bearings, collets and other small brass parts are now being made of powders. The lock industry is finding that such applications as tumbler pins and lock barrels can be made more economically by this method. The Victory medal, the Occupation medal, Theatre bars and the Merchant Marine medal are being made as pressed powder parts instead of the former method of stamping and coining. This use accounts for the biggest tonnage of brass powders.

During the past year, the production of metallic hydrides and the metal powders of titanium, zirconium, tantalum, columbium, and chromium have been gradually increasing and their chemical purity steadily improving.

Alloy powders such as chromium-nickel and chromium-cobalt have been used in larger quantities resulting in a greater uniformity in analysis and particle size.

Chromium metal powder of 99.6% chromium is readily prepared having a particle size between 15 and 50 microns. Seventy percent titanium-30% nickel alloy is being used in increasing quantities in magnetic materials through powder metallurgy techniques. Fifty percent cobalt-50% aluminum alloy powder has been found of potential value in catalytic chemistry of organic chemicals.

Nickel Alloys

Producers of nickel and its alloys are ever progressive. One of the most modern outlets is in the form of nickel-chromium alloys for gas turbines. Prominent among them are Inconels X and W, which were developed during the war when they were largely "hush hush." The X is: Nickel 73.00; carbon 0.04; manganese 0.50; silicon 0.40; chromium 15.00; columbium 1.0; titanium 2.5, aluminum 0.70 and iron 7.0%. It has high rupture strength and low creep under high stresses at 1200 to 1500 F; also high strength at room temperature. Inconel W is much the same, but with no columbium. Both can be forged, and are worked best at 2225 and 1800 F, respectively.

Monel and Inconel are increasing in demand for resistance to high temperatures and pressures and more powerful agents of corrosion such as flourine, the industrial uses of which are just beginning to be explored. It will have a tremendous outlet in television equipment.

During 1947 a new magnetic alloy, with permeability of 1,000,000 against 100,000 formerly, was introduced. It contains 79% nickel and has been used principally by the Navy. It gives a three-fold increase in the range of frequencies transmitted. Progress is being made in plating aluminum with nickel; also with chromium-on-nickel-on-plastics. Nickel electroforming is on the increase, while electrodeposited nickel foil is progressing from the development to the commercial stage. In India and the United Kingdom pure nickel

A weight saving of 60% is achieved by making truck tire flap curing rims of 2S aluminum rather than steel. In the American Welding & Mfg. Co. plant in Warren, Ohio, the rims are rolled from 3/16 in. flat aluminum strip and flash-butt resistance welded.

and cupro-nickel have replaced silver as standard coinage.

Other Alloys

On Nov. 26 the General Electric Co. announced a new alloy of tungsten, copper and nickel, with density 50% greater than lead, called "Hevimet." It is for construction of moving parts possessing maximum inertia and minimum size. It will be good for construction of balance weights to eliminate vibration in crankshafts, modern air screws, centrifugal clutches and other rotating parts. It has good tensile strength and machinability. It resists salt water, is easily plated with cadmium, chromium and nickel and can be silver soldered and brazed.

Progress has been made with chromium base alloys for high temperature service, they developing high strength in rupture tests at 1350 F and appearing the most promising for use in turbine buckets. The most serious defects are brittleness at room temperature and the need to melt and cast under high vacuum to avoid nitrogen and oxygen. Analyses have these ranges: Chromium, 55.00 to 60.00; iron, 25.00; molybdenum, 15.00 to 20.00%. The 60% chromium can be machined and processed in the chill-cast condition, provided proper care is exercised.

A new magnetic alloy with initial permeability several times as high as molybdenum Permalloy and Mu-Metal alloys has been supplied in apparatus used by the Navy. The analysis is: Nickel, 79.00; molybdenum, 5.00; iron, 15.00 and manganese, 0.5%. The metals are melted in a vacuum and poured in helium or nitrogen atmospheres. Used in communication transformers, a three-fold increase in range of frequencies transmitted and pulse duration three times heretofore resulted.

During 1947 "Elgiloy" appeared, a new watch spring alloy that is strong, hard, non-magnetic, highly resistant to corrosion and non-setting. Developed by the Elgin Watch Co., it contains: chromium, 20.00; cobalt, 40.00; nickel, 15.50; iron 15.00; molybdenum, 7.00; manganese, 2.00; carbon, 0.15; and beryllium, 0.03.

A new likely use for tungsten is in the form of carbide as inserts on tips of hammer drills. Heretofore the tungsten has proved too brittle to stand the double stress of hundreds of impacts per minute plus abrasion. Several well known companies are working on this project and have high hopes, the secret to be found in an improved matte. It is expected that this will account for a marked increase in tungsten consumption.

Welding and Joining

A new flux has been developed that overcomes the difficulty which has long vexed those who would like to solder zinc-coated surfaces. All zinc surfaces are somewhat difficult to solder but the problem is intensified when the zinc coating is passivated. Manufacturers of small parts such as radio components can now use less expensive materials in their assemblies now that they can be easily joined. The flux evaporates or sublimes at soldering temperatures. A pull of 1857 psi. was required to break the joint between two pieces of zinc-coated steel.

With the widespread acceptance of aluminum wire for interior electrical wiring came a problem which is now partially solved. Aluminum is excellent for electrical applications, but for a long time there was no simple foolproof method of soldering wires of the material. One new flux-less solder is said to be well suited to 2S, 3S and 52S aluminum alloys and its use is being investigated for other alloys. In addition to being useful in making joints, the material has been used with success in repairing aluminum castings. With Alsoco, as the solder is known, the aluminum to which it is to be applied is first tinned with the solder by rubbing molten solder on the surface. In the case of wires, the wires are dipped and twirled in molten solder. The parts are then reheated, additional solder applied, and the joints actually made.

Machining Nonferrous Metals

Despite the fact that many nonferrous metals are capable of being machined at high speeds, users of such metals have not been able to achieve the best production rates. With most nonferrous parts set-up and loading time far exceeds actual machining time.

An attempt to overcome the lost time in machining aluminum, magnesium and the copper alloys has been made by Warner & Swasey Co. with its Electro-Cycle turret lathe. The lathe has speeds up to 2,000 rpm. and features many automatic controls. For instance, the cycle of operation of the six turret faces is provided for through six control knobs. The machine has a fast braking action and speedy reverse to facilitate threading and tapping and subsequent retraction of the tool. An automatic spindle positioner

saves considerable time in aligning work.

In machining aluminum forgings production has been upped considerably through a time reduction of 217%. Similar increases have been established in machining brass forgings and bronze bar stock.

At the recent annual meeting of the American Society of Mechanical Engineers, the Aluminum Co. of America revealed some of the results of experiments in machining aluminum at high speeds. In their tests the company built a special lathe capable of speeds up to 20,000 surface ft. per min. Operating at top speed, the lathe gave a fine finish, indicating that even these speeds are not as high as is possible. At such machining speeds the problem of handling chips becomes acute, since a stream of small chips can be made to fly several hundred feet from the machine.

Plastics

A recent survey of the business picture in consumer goods reported that a buyers market had developed in plastics products among others. Production figures for the industry, combined with the results of this survey, lead to the hope that the plastics industry will be one of the first in the country to go through its "postwar slump" successfully. The volume of business done by the molders, particularly injection molders, started tapering off late last year, hit a low during the spring of this year, and has been climbing rapidly since that time. It is difficult to say whether it has returned to "normal" or not, because no one knows what "normal" is, or will be. It must suffice to say that most fabricators of plastics are doing a satisfactory volume of business, and that some have more orders than they can handle.

The consensus of opinion throughout the backbone of the industry is that the slump has helped the plastics industry rather than hurt it. There is a realization among the fabricators that they must return to sound principles in the selection of materials if they and the industry are to prosper. There dare be no more kitchen gadgets that fail to withstand ordinary dishwater, and no more industrial items that develop unsuspected weaknesses in service.

Materials Applications

One of the features of this renewed consideration of the applicability of the plastic to the use is the considerable expansion in the use of polystyrenes, especially in molded parts. With good toughness, and fair resistance to distortion at elevated temperatures, the new polystyrenes have been meeting with success in some applications where acetates, vinyls, and even phenolics were formerly used. Small radio cabinets have recently been molded of polystyrene. They can be injection molded, giving them the advantage of a fast cycle, while still possessing good heat resistance.

Polystyrene has also become a standard material for wall tile. A weight saving of more than 95% can be accomplished by their use instead of ceramic tile, and this is of importance in the building field as a labor-saving means, in addition to its obvious value in the transportation industries.

Woven filaments of vinyl polymers are beginning to find markets on a broad basis. One of the luxury automobiles is offering upholstery of the plastics fabric at the choice of the buyer. Railroad passenger cars are beginning to use the long-wearing material for upholstery as a matter of dollars-and-cents. Its use for screening is rapidly expanding after overcoming an unfavorable first reaction, due to use of an unsatisfactory material. The present screening is sufficiently tough and elastic to withstand repeated blows of a force that would cause metallic screen to stretch badly.

Transparent packaging is taking a substantial part of the output of polystyrene, vinyls, ethyl cellulose, and several other clear resins. With the anticipation of buyers' markets in many lines developing in the near future, manufacturers of consumer goods are giving increased attention to improving the appearance of their merchandise, and a tremendous expansion in packaging is one result. The attractive appearance of thin sheets of transparent plastics has made it the glamor material in this field. Sheet and film of vinyl polymers and copolymers continued to expand in the manufacture of novelties, toiletware, and wearing apparel.

Blended plastics, using phenols and nitrile rubbers, or vinyls and nitrile rubbers, or phenols, vinyls, and the same synthetic rubbers, have been making a place for themselves in the manufacture of tough, hornlike pieces such as automobile steering wheels; sheet materials requiring greater toughness than is usually obtained in rubbers alone, as for shoe soles and uppers for women's shoes; or for molded articles requiring flexibility with wear resistance, as in handles for electrician's pliers. A wide range of properties can be obtained by varying the percentages of the constituents, making the material even more subject to an exact tailoring to the needs of the specific article than is possible with the resin alone.

New heat-resisting polystyrenes were offered to the molder to fill the gap between the low-cost, general purpose molding compounds with low heat resistance and the earlier high-cost, higher-resistance copolymers. The new resin formulations can be molded in short cycles, will resist boiling water for a limited time, and cost only about 5¢ a lb. more than the general purpose thermoplastic molding compounds.

Phonograph records of molded vinyls, sometimes made with an aluminum core, staged a comeback, and made a noticeable impression on the market in competition with the shellac record. Manufacturers took advantage of the transparency of the material to produce it in a ruby-red color that is highly attractive, or is a clear covering over a color print on paper. Another vinyl laminate went into floor tiling.

Laminated phenolic resins turned up in many new applications, without any radically new materials being offered. A plastic mousetrap made its appearance in the market, and phenolics held a place in the production of toys along with the more easily molded thermoplastics. A survey showed that in several New York stores about four out of seven toys were made of molded plastics.

The price of polyethylene was lowered during 1947, and uses expanded considerably. As a film, it found a con-

siderable market when made up into refrigerator bags, where its pliability at low temperatures was of value. It also appeared in tableware, for which its translucence and acceptance of delicate colors gave an opportunity for attractive appearance.

New Equipment

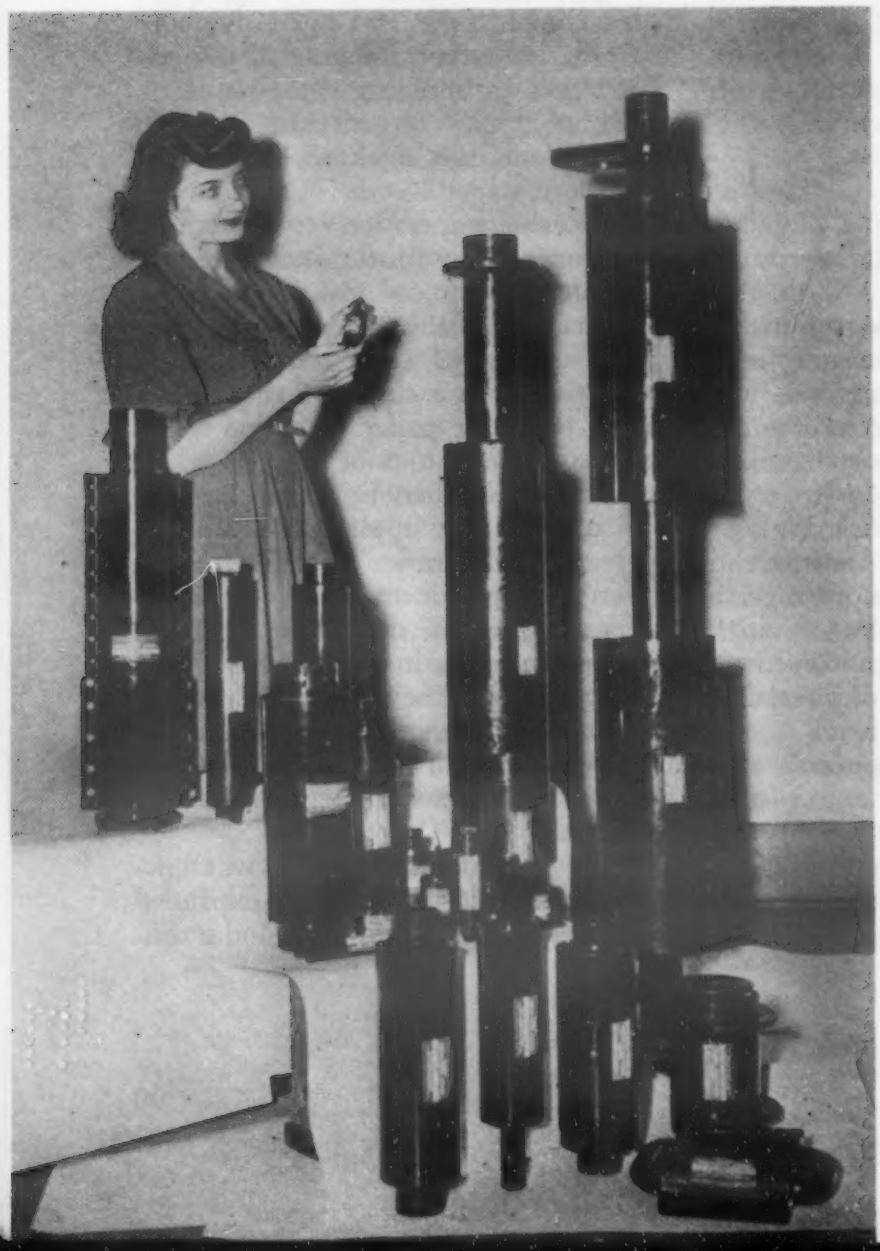
The use of accurately cast stainless steel molds for both injection and compression molding promises to simplify mold construction, and holds out the possibility of making molds at such a price that shorter runs will become profitable. The molds are cast from a wax pattern, and a finish is obtained that requires only touchup polishing for most work. Parting lines are made so accurately that the molds can frequently be used without any important costs for machining. Another development, this one promising competition to hobbing as a moldmaking procedure, is the use of sintered metal compacts for plastics molds. Results obtained so far seem to indicate that the cavities so produced can be compared, both in cost of mold and in quality of the work produced in it, with molds made by other processes, and offer advantages in some cases.

A machine to produce multiple-color extrusions in thermoplastics was announced. It is said to be suitable for all thermoplastic materials, and to produce a variety of color effects in the extrusion.

Other Nonmetallic Materials

Among the nonmetallics other than plastics, there was an increasing utilization of the war-made materials that were just reaching quantity production and availability for nonmilitary needs. The new developments in wood usage, where scarcities were still severe, included wide acceptance of compound lumber, in which planks were built up by gluing together many narrow strips of wood. This process, a direct result of the scarcity of wide planks, permits the use of material formerly regarded as waste. Its success is due to the advances in technology of resinous adhesives, which are completely waterproof, and to the expanding use of dielectric heating, which permits heating the flue film in thick sections of wood without waiting for the heat to penetrate by conduction.

The wood-metal and other composites have experienced a great growth, with plywood faced with aluminum or stainless steel now going into about 90% of the new railway passenger cars. It is used for interior partitions, interior doors, and trim. The same composites are being generally used in automobile trucks and trailers and aircraft also. A new version of the low-density core type of composite went into limited production with the use of paper, aluminum foil, and woven fabric in a honeycomb construction for the core material. These composites combine great stiffness with extremely light weight, and have won a place in aircraft construction. They are still too costly to be widely used except where weight saving will pay a high premium.



One of the newest uses of rubber is in springs manufactured by B. F. Goodrich Co. The springs consist of two cylinders —or a shaft and cylinder — with the space between them filled with rubber permanently bonded to the metal. One metal part is held in fixed position while the other is free to turn under applied weight. All springing is accomplished by the twisting movement of the rubber.

Rubber—Synthetic or Natural?

The question of what amount of our wartime synthetic rubber production could pay its way in competition with natural rubber remains unanswered, because the rubber industry has not yet been permitted to return to the conditions of a free market. The Office of Materials Distribution of the Department of Commerce still requires automobile tire manufacturers, by far the largest users of rubber, shall use only a small percentage of natural rubber. In this way a forced market is kept open for the synthetic rubber, and a predetermined part of our synthetic rubber manufacturing capacity is kept in operation. The percentage of natural rubber is fixed at a maximum of 23% in popular sizes of passenger car tires, and varies from only 13% in rear farm tractor tires to 100% in the largest sizes of aircraft and intercity bus tires.

A clue to the opinion of industry about the merits of natural rubber as against synthetic may be found in the strenuous efforts of the tire manufacturers to have the permissible percentage of natural rubber to 50% or higher. Synthetic rubbers have special properties that makes their use advantageous over natural rubber, such as resistance to oil or gasoline in some types, better resistance to deterioration by heat and light, and lower permeability. Even before the wartime curtailment of supply of natural rubber, the

synthetic product had established itself for gasoline hose, gaskets, and other articles. At present, about 42% of the total consumption of rubber is the synthetic product.

Glass Developments

Announcement was made of the development of a photosensitive glass during the year, and this product is expected to become important in the manufacture of containers, stained glass windows, decorative plaques, and similar articles. The picture is developed in the glass by exposure to ultra-violet light, and the image is fixed by heating the glass to about 1000 F for several minutes.

An electrically conductive glass, developed during the war to help in defrosting aircraft windshields, has been installed in several types of luxury automobiles for the same purpose. The material serves as a poor conductor, and the heat created by its electrical resistance defrosts the windshield.

A glass fiber tubing, fireproof but flexible, has been produced for electrical applications.

Industry is evincing increasing interest in another war development now released from restrictions. During the war an enamel was developed to give protection to ordinary low-carbon steel when used for high temperature service in aircraft and tanks. The carbon steel, so coated, gave satisfactory service for exhaust stacks and collector rings, saving high-alloy steels that otherwise would have been necessary. Temperatures of 1000 F and higher were encountered in service, and in tests the new enamel gave satisfactory protection under prolonged exposure to 1250 F.

Composition of the enamel has now been released. It is a mixed oxide formulation rather high in alumina. Experience has shown that it must be applied in thinner coats than standard enamels, with best thicknesses between 0.002 and 0.003 in. The steel should be below 15 points carbon content, but many of the alloy steels have been successfully used as a base.

A process for spraying molten glass onto metal surfaces, also used during the war for metal protection, is now being offered to industry. A pneumatic sprayer resembling the gun used for metallizing will deposit the glass much as paint is sprayed onto a base material. It is claimed that the same gun will spray molten plastics or metals also.

A wall covering of 32-gage steel coated with enamel has been produced experimentally, and may become commercial within a few months. It can be rolled without cracking.

Porcelains that have shown satisfactory properties at temperatures to about 2000 F have been announced at the Bureau of Standards, Washington. They are made with high percentages of oxides of beryllium, zirconium, thorium or aluminum, and without silica. They have not yet been taken up by industry, but are prospective high-temperature materials of the future.

Fabricated Materials and Precision Parts

During 1947 economics once again reigned supreme in the applications of the different types of precision parts and of the various fabricated forms of materials. However, the return of several kinds of "shortages" suggests that expediency may soon become once more a major factor in choosing among castings, forgings, stampings, metal powder parts, etc. for industrial products.

Outstanding trends in the fabricated materials field—in addition to the above-mentioned triumph of the cost factor—are: (1) A tendency for manufacturers to install their own special-parts manufacturing departments instead of purchasing the parts outside. This is traceable to difficulty in obtaining quickly certain types of castings, and has resulted in important additions to the ranks of "captive" precision casting, die casting, powder metallurgy and plastics-molding operations. In some cases, however, the expected solution to the problem has not been achieved. The reason parts-manufacturing job shops were unable to keep up with their customers' demands has often been shortages, sometimes temporary, of *their* raw materials; exactly the same kind of shortage faces the new "captive" departments (sometimes worse, because of the absence of an established supplier-customer relationship).

(2) Continuing efforts to find suppliers or ways of making precision parts that will involve the use of standard fabricating equipment with changes in tools, dies and molds, instead of using special-purpose machine tools designed all-in-one-piece for a particular job. For the more complicated shapes, where the lot sizes are in the "few-thousand" range, this has turned the spotlight of favor increasingly on precision investment castings.

(3) Growing attention to weight-saving in the choice of part type or fabricated form of material. In the aircraft field this is occasionally the chief reason forgings are chosen over castings. Die castings of aluminum or magnesium result in improved strength without adding weight. Molded plastic parts often provide a favorable combination of low weight, good physical properties and low cost. And one experienced designer reports savings of up to 40% in weight by using formed sheet metal sections in U and J shapes instead of the traditional extruded shapes for aircraft components.

(4) Increasing, sometimes spectacular, activity in the fields of tubing, centrifugal castings and assemblies fabricated by brazing or welding.

Die Castings

During the year F. C. Ziesenheim presented a valuable review of the present status of die castings application, now responsible for something like 25% of the total output of nonferrous castings. Of the die castings now being made, the proportions of zinc alloy to aluminum alloy castings are about 3 to 2, with consumption of magnesium, brass, lead and tin die castings trailing far behind. Die castings of all types can now be completely sound structurally, with the use of die casting machines that exert pressure on the casting as it chills.

Large die castings continue to attract much interest, according to Ziesenheim, with automobile body panels and cylinders for hydraulic brake systems being experimentally cast. However, a trend is evident toward assemblies of smaller die castings instead of super one-piece jobs, for example, for radiator grilles. The building industry is

using increasing amounts of die cast zinc hardware in place of brass and steel parts to circumvent the shortages in those materials and, incidentally, to reduce costs as mass production of building hardware becomes a reality. Brass die castings themselves are the subject of continuing study. Object: to develop die materials that will make the die casting of brass inexpensive enough for its technical advantages to be utilized on a more extensive scale than is now economically possible.

A survey made by *Die Castings* magazine showed that where die castings replace other types of parts the victims are sand castings, machined parts, stampings, plastics and forgings in that order. Redesign trends appear to favor zinc for automobile die castings, zinc for electrical products, aluminum and zinc for household appliances and precision instruments, aluminum for light machinery and business machines, and, of course, aluminum and magnesium for aircraft parts.

Interest in tiny die castings continued to increase. Zinc alloy die castings weighing less than ½ an oz. and produced at rates up to 100 pieces per min. in single-cavity molds are being used more and more for such parts as umbrella tips, button shanks, hollow-end rivets, wing nuts, collar buttons, etc.

One of the most interesting new applications of aluminum die castings was a one-piece electrical rotor die casting. The cage, bars and end connectors are integrally cast and require no assembling or fasteners. In addition to its production advantages, the rotor is light in weight and its parts do not "move" relative to each other in service.

Of potentially broad significance is the current preference for aluminum die castings over iron sand castings by certain manufacturers of gasoline engines. Raw material costs are greater for the die castings, but this difference is more than offset by savings in machining and set-up time.

Among the new equipment introduced during the year was a new die casting machine convertible from cold chamber to hot chamber injection. The machine uses injection pressures from 3400 to 11,800 psi., and can cast up to 11.6 lb. of aluminum or an equivalent volume of other metals. The convertibility feature adds considerable versatility since zinc, tin and lead on one hand and aluminum, magnesium and brass, on the other, can be cast with the same machine after a simple changeover.

Other "Precise" Castings

Precision investment or "lost wax" castings, which had their ups-and-downs in the year following the war, are again heading into an "ups" phase. The technology of the process has been improved considerably. The trend is toward larger, more mechanized operations, close technical control of all steps and materials, and more realistic design practice.

Engineers are coming to realize that precision castings are no cure-all for every parts-manufacturing problem. They have their place. It is, however, an increasingly important place, especially with "engineered" applications coming more and more into the picture. Look for a 1948 increase in interest in and use of precision castings, especially for parts of extremely intricate shape which must be made of material relatively hard-to-work by other methods.

Permanent mold castings are still chiefly available in aluminum alloys, but an increasing number of permanent mold castings are now made of *iron*. Zinc alloy permanent mold castings, too, are becoming of greater interest for applications where lot sizes are smaller than would justify the tooling costs of die castings, and where the finish must be better than sand castings can provide.

Typical of the kind of "substitution" that is going on is the use of aluminum permanent mold or die castings in place of sand cast iron for burners for cooking stoves. The replacement is directly due to the difficulty in obtaining iron castings. When the burners are properly designed the aluminum castings perform perfectly. They may retain a good share of this market even when conditions return to normal.

Centrifugal castings have been recently applied in several products new to this method. Outstanding are centrifugally cast gray iron piston rings (described in a feature article in this issue), which offer time-saving, cost and mechanical quality advantages. The "pancake" motor of Fairbanks Morse incorporates copper rotor bars, which are centrifugally cast into a punched strip steel rotor. Welding rods are now being centrifugally cast, using a new turntable type of machine that is able to produce 1500 lb. per hr. of finished rods.

Other centrifugal casting developments include (1) the manufacture of small parts by a combination of vacuum processing and centrifugal casting, whereby almost any material can be employed and high purity of metal retained, and (2) the use of centrifugal casting as a means of making stainless steel tubing. And here's a brand new one: *Plastics* are now being centrifugally cast for short-run orders, models, and parts that are too large for other plastic-forming methods.

Iron and Steel Sand Castings

The production of gray iron sand castings in 1947 was close to 13 million tons, about 25% more than 1946 and close to the war-time record. Demand continues strong. Gray iron castings are losing some applications to the more precise forms but they are also gaining new uses steadily as engineers regard them with increasing respect as high-grade engineering materials.

Among the "tightest" of materials today are malleable iron castings, which are trying to meet an unprecedented demand and gradually reducing their backlogs.

During the year the Steel Founders' Society completed and published an extensive investigation of the properties of commercial carbon and low-alloy steel castings. The hardenability of cast carbon steels is generally similar to that of equivalent wrought steels. Cast alloy steels have higher hardenability and strength and slightly lower ductility (after heat treating) than comparable wrought steels. Steel castings have excellent notched-bar impact properties at low temperatures; their impact strengths are higher than the wrought steels when the latter are tested transverse to their rolling direction; when the wrought steels are tested parallel to the direction of working the wrought steels are superior. For many alloy steel castings ductile fractures were obtained at temperatures below −185 F, after a liquid quench and temper heat treatment.

Forgings and Stampings

Precision forgings, primarily for high-temperature parts, and the new super-size aluminum and magnesium forgings held the 1947 spotlight among forged materials. Data were released on the development of precision-forged jet engine buckets of Hastelloy B, which were found to have better fatigue, impact, and grain size for these larger parts than did the precision cast-

ings (which have demonstrated their superiority for the smaller supercharger buckets). Other materials that have been successfully precision forged include such cobalt alloys as S-816 and Vitallium, while precision forged stainless steel nozzle diaphragm blades and compressor blades have also been made.

Now replacing cast or machined automobile or aircraft parts that were formerly impossible to forge because of their size are large press forgings of aluminum and magnesium—some of them weighing 550 lb. each. A gas turbine impeller forging of 25S aluminum and a magnesium base-plate forged from A280X extruded stock (8 in. in dia.) are examples of the kind and size of parts now being made on Wyman-Gordon's new 18,000-ton press.

Stampings are aggressively finding new applications. New uses include bathtubs (now a sizeable outlet) and burners for domestic gas ranges. The latter employ copper-brazed steel stampings which require no machining, provide good surface, dimensional accuracy and mechanical quality, and are cheaper than iron castings. Typical of the wholesale use of stampings in new products is a room heater, for example, which contains 20 stampings and formed metal parts of steel or aluminum, assembled by welding, riveting and clinching.

Deep-drawn magnesium parts now being manufactured include several formerly made of other materials. Typical is an oil filter, formerly made from aluminum sheet, stamped and spun. Redesigned to use drawn magnesium parts, the new filter is not only one-third lighter but is cheaper and gives better service as well. Methods have recently been developed for drawing magnesium sheet at room temperatures, using several intermediate stages during the forming.

Small lots of stampings needed quickly and inexpensively can be made in bismuth alloy dies which are surface hardened by dipping in liquid nitrogen at −320 F. Such dies will produce up to 10 stampings before softening of the die begins and re-chilling becomes necessary. Experimental stampings can be obtained this way in 24 to 48 hr., instead of the customary weeks.

Extrusions and Tubing

Extrusions of all types — extruded steel parts, impact extrusions, extrusions to be sliced up into intricately shaped parts and extruded structural shapes—were the beneficiaries of technical development last year. An originally German process for the cold extrusion of cup-shaped steel parts is being developed in this country by Heintz Mfg. Co. The process is good for parts to be made on a mass-production scale, with sections that are expensive or difficult to make by machining or deep drawing. It was first used by the Germans for steel cartridge cases, and later for landing gear cylinders.

Magnesium extruded shapes now include bars, tubes and special shapes, many available from stock dies. Their weight-saving and production advantages are currently applied in a wide range of products, including a magnesium ladder which is unusually stiff and light, I or T truck body panels, window cleaners, magnesium chairs, bathinettes, textile machine bobbins and others.

Structural extrusions of copper, aluminum and magnesium, and in recent years zinc, alloys have been typical of materials available in this form. During the last year considerable commercial work was done with extruded stainless steel tubes (3 to 8 in. O.D.) as well as with extrusions of other alloy steels and nickel-base alloys. These are extruded at temperatures up to 2400 F in fast-working presses using high-quality and expensive heat- and wear-resisting tools.

Tubular forms in general attract increasing attention from materials and design engineers. Welded tubing is the preferred structural form for much of the new metal furniture. The advantages of formed tubing in eliminating machining are now applied to several types of small parts and tool steel tubing, used for the same reason, is becoming an important item of commerce. With its eye on the applications of tubing in precision parts, the National Tube Co. is now constructing a new seamless tube mill which will produce tubing with thinner walls and greater precision than have previously been available.

Molybdenum became commercially available in the form of seamless tubing in sizes from 0.04 to 0.500 in O.D. and in lengths up to 9 in. This moly tubing is machinable, can be worked into shape readily, and is easily welded to other metals. It is exceptionally strong (T. S. 180 to 250,000 psi.) and successfully resists several acids and alkalies.

Other tubing developments are described in a subsequent section on "bearings."

Metal Powder Parts

Powder metallurgy is still following its post-war line of development with more progress being made in the specialty uses than in the production of machine parts in competition with conventional fabricating methods. However, a few manufacturers and engineers with imagination and a sound technical approach to metal powder parts design have done some startling things with machine parts. This has been especially true in the manufacture of small brass parts for precision instruments, clocks, watches, etc., and in the use of iron parts for simple, usually self-lubricating, products. A distinct trend is evident in this field toward the installation of metal powder fabricating departments by product manufacturers. There is a growing interest in steel powders and in parts pressed from tungsten and related carbides.

With Swedish iron now available in substantial amounts at about 8c per lb., the general feeling in the industry is that there is now more American iron powder producing capacity than the market can absorb for a while at the present price for the American grades (somewhat higher than the Swedish iron). Although most metal powder parts employ copper-base powders, the ratio of copper powder to iron powder consumption would be reduced and the general applications of powder metallurgy considerably increased if iron powder production, consumption and price could be brought into more desirable balance.

One outstanding application trend is the use of metal powders for large-scale production of molds for the molding of plastics. Here powder metallurgy competes with machining, casting or hobbing. Molds made by powder metallurgy employ electrolytic iron powder, are resintered and re-coined several times, carburized and hardened, to give transverse tensile strengths in the neighborhood of 130,000 psi. Powder metallurgy for making these molds is advantageous on high production jobs or those that are difficult or impossible to produce by conventional methods; otherwise hobbed cavities are preferred.

The Ford Motor Co.'s process for making oil pump gears by re-striking

iron powder parts was announced during the year. It is essentially an extrusion process applied to metal powders. Federal-Mogul's method of making steel-backed copper-lead bearings from metal powders was shown to be less troublesome than melting and pouring the alloy, especially at high lead contents, and to achieve uniform dispersion. Federal-Mogul employs a continuous process in which a new type of pre-alloyed copper-lead powder is used, the final mechanical properties being higher than by centrifugal or gravity casting methods.

Progress was reported in the making of filters from stainless steel powder using a pre-alloyed 17½ chromium, 9% nickel, low carbon powder. Precast powders and pre-alloyed powders, in general, are arousing steadily increasing interest among parts fabricating engineers.

Cemented carbides are fast becoming important materials for several types of wear-resisting parts all made by powder metallurgy methods. These include rolls, bearings, guides, rests, jewels, etc. A typical new use is for making grooved carbide sleeves for rolls employed to roll tough alloys like stainless steel, nickel-chromium, etc. One electronic equipment manufacturer increased the life of his rolls 50 times as compared with hardened steel rolls, by making them of tungsten carbide.

Semi-conducting parts made by mixing conducting powders with insulators, pressing and sintering, are relatively new and provide materials and products which have controlled electrical and thermal properties impossible to achieve in any other way. Some of these parts are made by starting with a non-conducting oxide of a metal and then partially reducing it to a lower oxide which is conductive and which makes the material as a whole a semiconductor with a favorable temperature coefficient of resistance.

The application of the powder metallurgy method may be extended to larger and more irregular cross-sections than have previously been possible through the development of a new press for complex parts announced during the year. The press combines the advantages of triple hydraulic lower motion built into a 345-ton mechanical press. The press is described as a close tolerance machine as well.

Some interest was shown in the use of plastics molding powders as helpful additions in metal powder pressing. One report stated that the addition of 5% by volume of 200-mesh polyvinyl acetate molding powder improved the flow and reduced the final porosity of metal powder parts. The resin can be burned out at low temperatures and the piece de-gassed and re-compacted in a 3-min. cycle. It is said to be in use now in making carbide parts, high density corrosion resistant materials and bearings.

Bearings

Developments are coming fast in the bearings and bearing materials field. S.A.E. recently published a breakdown of the proportionate use of the "tubing method" (by which steel tubes or bronze castings are lined with bearing alloy) and of the "strip process" (in which long steel strip is moved continuously through a mill which applied lining material to the bearing), for lined sleeve-type bearings. The percentage of such bearings made by these methods and in various materials was reported as follows:

Bearing Lining Material	Tubing, %	Strip, %
Tin-base babbitts	5	10
High-lead babbitts	6	54
Cadmium alloys	4	2
Copper alloys	1	4
Copper alloys—overplated	2	10
Aluminum alloys	1	1
Silver	—	—
Silver — overplated	some	some

Aluminum bearings are still under trial and show increasing promise for large-scale engine bearing work. "Steel wool" bushings in which steel wool is pressed and then impregnated with liquid copper were described during the year. The bushings are copper-brazed to tubing and represent an inexpensive material capable of withstanding reasonably severe service.

A British report based on a 10-year service study of molded resin-fabric bearings used in place of white metal bearings in British steel making equipment showed the resin bearings to be lower in initial cost, to last 2 to 3 times as long, and to require only one-fifth the time to replace them. Other savings included a reduction of one ton of grease consumed per week and a 19% saving in power consumption. In this country nylon in tube and molded form is being successfully applied as a bearing material.

Developments in powder metallurgy bearings were described in earlier paragraphs.

Welded and Brazed Products

Perhaps the foremost development from the point of view of future application of weldments was the vindication of welding as a construction method embodied in the Navy Department's report of the investigation of the fracture of welded merchant vessels during the war. The fractures were shown to be caused by notches in design and by the use of steel which was notch sensitive at operating temperatures. Poor workmanship was occasionally, but not characteristically, the cause of these notches. Locked-in stresses were not found to be a major cause of failures. The report concluded that with proper detailed design, with the use of steel of low-notch sensitivity and with high quality workmanship, all-welded ships will perform with entire satisfaction and are, of course, cheaper to construct on a mass-production basis.

The more general use of welded steel assemblies was stimulated by Westinghouse's announcement of a new basis for motor design and construction in which sand castings were entirely replaced by steel formed by rolling and drawing and then assembled by automatic welding. The new motors are 35% smaller than their predecessors and have improved performance and appearance.

The railroads, traditionally users of heavy steel forgings or castings wherever possible, are now using several large parts that have been fabricated by welding. For example, draft gear, now approved by the A.A.R. as made by forming and welding, is the lightest type of draft gear ever to receive such approval. The weight saving is about 400 lb. per car or equal to 12½ tons in a 100-car freight train. This draft gear is fabricated from steel tubing which is upset, welded to formed strip steel, and this assembly welded to a steel base-plate.

Many new products are being made as brazed aluminum assemblies as engineers come to realize that brazing is an excellent means of fabricating aluminum for many parts. Typical of this is the case of a torque converter for busses which now comprises three pieces that are brazed together and heat treated. The cost is less than one-half that of the casting replaced and per-

formance is described as superior.

Fabricated Plastics Parts

There is an evident tendency for the maximum sizes of plastics parts, whether formed or molded, to increase. This is especially true of formed laminates, such as are increasingly used for refrigerator liners and panels, architectural components and boat sections. One special product, a resin-bonded glass fibre part for a new atom-smasher, is 8 ft. in dia. and weighs 650 lb.

Demand for injection-molded parts is steadily increasing because of the several advantages of color, absence of finishing, light weight, moldability in thinner sections, and faithful reproduction of intricate designs provided by such parts. The increasing popularity of this form has been aided by the shortage of thermosetting materials (which are usually compression molded) and has led to several new uses of injection molded parts for radio cabinets, refrigerator components, toys, nursery equipment, etc.

Cast plastics are making great progress, especially for foundry patterns and metal-forming tools. A new casting resin was developed by the Bureau of Standards as a potting compound and provides an excellent combination of mechanical properties and electrical stability for high frequency electronic applications. Low pressure laminates are increasing in use, as are parts fabricated by machining laminated plastics. The latter use regular metalworking machinery; the laminates are press formed to simple shapes (occasionally post-formed for deeper draws) and then machined.

Plastics extrusions, once applied only to thermoplastic materials, were widely applied to thermosetting materials during the war, especially for rocket tubes. Their newest use is for clarinet tubing. The tubing is extruded from phenolic materials and when made in this way is said to have several advantages over rubber, metal, or even the best grade of wood for these musical instrument parts. One switch away from extruded plastics is in the manufacture of plastic cups for forming ice cubes. Formerly extruded and formed to shape, these are now made by molding in 12-cavity molds to give increased production and reduced cost.

Nylon can now enter industrial products in several fabricated forms. Nylon can be had as a molding powder and in the form of molded parts, rods, tubes and sheet, in addition to the familiar filamentary products. Molded nylon parts are being tried or used for faucet washers. Hammer faces are machined from rod or bar stock, or sometimes molded. Injection molded nylon is advantageous for gears and bearings if the production runs are large, otherwise such parts may be machined from nylon bar or tubing, often on the same equipment as used for brass. The material is strong and has especially good damping capacity.

Bar Stock, Wire and Other Forms

One of the most interesting new uses for bar stock is in the making of automobile starter ring gears as carried out by Studebaker. In this process hot rolled steel bars, 20 ft. long, are rolled into a 6-turn spiral, cut to give 6 near-circles, and pickled. Each near-circle is then pressed into a plate and butt-welded to form the circles that become the gear blanks. These are expanded, re-struck, machined and induction hardened. This ingenious process saves much time and increases the yield as compared with making the gears completely by machining.

A growing use for steel wire is to "bind" automotive pistons. Composite pistons are made with a 0.040-in. wire cast integrally with aluminum pistons to reduce blow-by.

The trend in bolt and heading wires is for intricate and complex parts to be made by cold upsetting rather than by screw machine work. Spring makers are using finer gage wires with higher tensile strengths than formerly and demand a greater uniformity of temper and size. The availability today of piano wire, valve spring wire, music wire and other high carbon wires previously procurable only from Sweden is an outstanding current achievement in the wire field.

A development which may have a somewhat adverse effect on the use of wire in time is the "printed circuits" idea now going into peace-time commercial application for radio sets, hearing aids and other electronic devices. Printed circuits are a method of fabricating electronic and electrical units using ceramic, plastics, or other nonmetallic plates that are *printed* with silver ink, in place of using wire conductors wound around an insulator. The new technique, developed and applied during the war for the Navy's proximity fuze, eliminates 60% of the soldering and much of the fine wire usually required for small electronic components.

Finishes and Coatings

Protective and decorative finishes and coatings in recent years have taken on new and added importance in the metalworking industries, and this past year was no exception. A number of promising developments were introduced and hundreds of new proprietory products—too many to mention here—were announced.

A continued trend towards considering finishes as engineering materials was noticeable. The finishes for parts are being planned as part of the structure and are being selected with the same care that is used in picking other basic materials going into the product. This is resulting in more "tailor-made" finishes—particularly in organic finishes—designed to meet specific service requirements of the product.

In the metallic coatings field, zinc advanced steadily as an ingredient in protective coatings. A group of new tin-zinc coatings for protecting steel from rusting were developed. The compositions found to be most successful were those containing 80 tin-0% zinc or 50 tin-50% zinc. These coatings have been used on steel chassis for radio sets, and for a variety of steel electrical equipment. The coatings can also serve as a foundation for nickel-chromium plating where high temperature service is not involved.

A new zinc-base finish, although developed a couple of years ago, saw increased commercial application this year. The finish is obtained by first zinc plating the object using normal procedures. After the regular plating operation, the part is placed in a chromate-type bath which results in the electrolytic formation of a zinc conversion coating. The resulting finish is highly corrosion resistant and has a

bright metallic appearance somewhat similar to that of chromium plating.

Zinc is also seeing wide spread use in flame spraying of both structures and manufactured products. A recent development has been the mixing of zinc powder with aluminum or plastic powders. Using these combinations, some unique coatings have been obtained, possessing improved protective properties as well as new decorative effects.

Nickel and chromium plating have also increased in use during 1947. Preliminary examination of exposure tests by technical societies and companies have showed that heavy nickel layers under chromium increase the life of the plating in corrosive atmospheres.

Plating on Plastics

Metal plating on plastics is expanding in the electrical and electronic industries as well as in the costume and novelty jewelry field. During the year a new process to produce a copper film on plastics by chemical reduction was announced. Previous formulations were not commercially feasible and so silver has been commonly used. By this new process an initial copper film is put on the plastic instead of silver. An intermediate layer of copper or silver is then applied, followed by the final layer of metal. The process involves reduction of copper from a Fehlings solution with a metallo-organic derivative of sodium hydrosulfite. The method is said to be cheaper than silvering. Also, a thicker copper film with better adhesion is possible.

For manufacturers who have mixed metal production a new phosphate coating solution has been developed which can be used for the simultaneous treatment of steel, aluminum and zinc. The solution is not radically different from the standard Bonderizing solution for treating steel. The bath formulation is changed slightly; an accelerator, a fluorine bearing compound, is added to get a rapid etch on aluminum. The advantages of this new solution are obvious. It eliminates the necessity of handling different metals in separate loads or on separate lines, thereby saving time and cutting production costs.

Another chemical surface treatment recently announced is an oxidized finish for sterling and silver plated products. The finish is black-to-gray in appearance. It is obtained by dipping the parts in a special chemical solution; no electric current is used.

Ceramic Coatings

Work on ceramic coatings, for low and high temperature service, progressed during the past year. Much interest has been shown in developing a satisfactory porcelain enamel for aluminum. Thus far, those tried have not been too successful, and so development work is continuing.

High temperature ceramic coatings are still relatively new. New formulations are being announced periodically. A group of all-crystalline porcelains, having high mechanical and dielectric strength at temperatures up to 2000 F, have been developed at the National Bureau of Standards. Compositions of the new porcelains involve such materials as alumina, beryllia, zirconia and thoria with minor additions of other metallic oxides, but do not include silica. Representative compositions are the high beryllia type containing 84 beryllia and 8% zirconia, and the high zirconia type containnig 10 beryllia, 10 magnesia and 80% zirconia.

The coatings are highly resistant to deformation or creep at temperatures up to 1800 F for long periods of time; they also have high thermal shock resistance. They are good for such applications as electrical insulators, aviation spark plugs and radar transformers. (See feature article on high temperature ceramics in this issue).

In the organic finishing field, as in other years, a vast variety of new paints, enamels, lacquers and varnishes were introduced. A large number of these are not strictly new, but rather are improvements or additions to existing formulations, giving better service and processing properties and characteristics, or adding a new decorative effect. Because of their great number we cannot list them specifically, but can only speak of general developments and mention a few specific examples.

Synthetic Uses Increase

In general, the trend during the year continued towards synthetic type finishes and away from the strictly natural resinous types. A number of improvements were made in synthetic resins for coatings. A new vinyl resin for fortifying nitrocellulose lacquers was developed, which makes possible lacquers that exhibit properties formerly possessed only by vinyl resin coatings. The resin is a copolymer of vinyl chloride and vinyl acetate, marketed as a 40% solids solution in butyl acetate. Perhaps its most important attribute is that it increases resistance of lacquers to severe and prolonged exposure.

New high solids vinyl resin coatings have also been introduced. They run up to 25 or 30% solids as compared to the older vinyl resin coatings which had only 10 to 20% solids. This added solids content increases the coverage, hiding power, gloss, build and flow-out of the coating. The coatings employ vinyl chloride-acetate resins dissolved in thinners which contain high boiling solvents. They are baking finishes and find use for coating products such as refrigerators, washing machines and other household appliances.

Another new vinyl type coating that has good adhesion to practically all metals without the usual chemical pretreatments was announced within the past three months. The finish also features a high solids content with resulting high coverage and hiding power and a short baking cycle. (For further details see the feature article on this finish in this issue).

In the past, brushing lacquers have generally not been satisfactory because of their poor brushibility, low solids content and too rapid drying properties. New formulations were developed during the past year or so that go far towards avoiding these objectionable properties. The solids contents have gone up to 30 and 35%, drying time has been reduced, and brushing properties have been improved so that brush and lap marks are practically eliminated.

A number of improved rack coating materials of both the enamel and lacquer type were announced. These include a synthetic type coating with extra heavy thickness; it is 100% solids and has no volatile solvents. Another is a vinyl type reported to give a tough flexible surface that has high resistance to physical damage and can withstand 90 F bends without cracking.

Also announced was a new heat resistant paint for protection of metal against corrosion and scaling at temperatures up to 1850 F. In addition, the coating can withstand sudden temperature changes, caused by quenching for example, without cracking. And finally, a group of alkali resistant enamels for coating industrial machinery was introduced. The coatings have a plasticized rubber-base vehicle and are reported to withstand the severe service conditions to which industrial equipment is subjected.

MATERIALS & METHODS

DIGEST

A selective condensation of articles — presenting new developments and ideas in materials and their processing — from foreign journals and domestic publications of specialized circulation.

Edited by H. R. CLAUSER

A New Method of Non-Destructive Spot-Weld Testing

Condensed from "Metallurgia"

Previous methods of testing spot welds in austenitic steel sheets have been destructive tests on representative samples and X-ray examination of routine welds. Welds showing cavities in the spot upon X-ray examination always proved to be the strongest welds on subsequent destructive testing. The disadvantages of the radiographic method are its cost and the time required to obtain results.

It was found, however, that there is a good correlation of the radiographic and destructive tests with the magnetic properties of the weld. The better the weld, the greater is the change in magnetic permeability at the spots. A Metroflux captive fluid magnetic detector cell provides a satisfactory and simple magnetic detector for this purpose. This cell consists of a transparent plastic molding in the form of a shallow dish with a thin diaphragm forming a back that is usually opaque and white. The cell is sealed off and contains a small quantity of black magnetic fluid made up of minute magnetized particles suspended in a light oil.

If this detector is laid on the magnetized sheet containing a spot weld, the magnetic particles will reveal the magnetic spot as a particle pattern on the diaphragm. Since this will occur only if the magnetic properties at the spot differ appreciably from those of the parent sheet, the detector shows up those spots that have reached a high enough temperature to produce satisfactory welds.

Two types of particle patterns have become known, depending upon the direction in which the external magnetization is made to traverse the spots. In the black spot technique, the flux from the exciting magnet is made to flow axially up to the spot normal to the sheet surface and into the detector cell. The more permeable spots appear as black spots against a white background. In the white spot technique, the flux is made to flow diametrically across the spot parallel to the sheet and the bottom of the detector cell, so the spot appears white. Though either can be used, the black spot technique is preferred since there is then no likelihood of a bursting bubble in the cell being mistaken for a white spot. This method of ensuring soundness of spot welds has been widely used and is quick, simple and reliable. (A. M. Armour. *Metallurgia* (British), Vol. 36, Sept. 1947, pp. 273-275.)

Stress Corrosion in Materials

Condensed from "Metallforschung"

Based on numerous examples, it is shown that there is in general no lower limit of stress below which a sensitive material can be considered as absolutely resistant to stress corrosion. Practically, however, the life increases so markedly at lower stresses that a satisfactory degree of safety under usual corrosive conditions can be reached. Tests also show that notches do not increase the danger of failure by stress corrosion.

In stress corrosion, the magnitude of the stress is just as important as the influence of the corrosive medium or the condition of the material. Therefore, stress corrosion cannot be considered only as an electrochemical solution process. Similar failures occur in synthetic resins as well as in metals after brazing and welding where there is no electrochemical action. A failure by stress corrosion should therefore be considered as a genuine failure similar to failure due to fatigue or corrosion fatigue.

In tests made to clarify the danger of failure under conditions of stress other than tensile stresses, the failure always occurred as a normal stress (tensile) failure with the rupture planes perpendicular to the direction of the main tensile stress. The danger of failure is not determined simply either by the normal stress hypothesis nor by any other strength theory, because the sensitivity to stress corrosion is dependent to a large degree on the plastic deformation.

The following rules apply to the stress corrosion of homogeneous solid solutions: (1) Stress corrosion can be caused only by a corrosive medium that attacks the solid solution. (2) The greatest danger exists with solid solutions based on an element less noble than the alloying element which composes the smaller portion of the solid solution. Here every corrosive medium can cause stress corrosion. (3) The danger of stress corrosion also exists for solid solutions based on an element nobler than the alloying element; however, in this case, the danger depends to a large extent on the type of corrosive medium.

Accordingly, the possibility of producing homogeneous alloys insensitive to stress corrosion is very slight. It is confined principally to alloys based on gold, platinum and palladium. Silver alloys are insensitive only when they contain less noble alloys. Alloys with only a very slight potential difference between the components are insensitive to stress corrosion. With all other alloys based on the common elements, there is a fundamental danger of stress corrosion. It can be minimized only by special properties of the alloys (high plasticity or the formation of a passive protective coating) or by suitable precautions such as annealing, cladding or cold working.

Heterogeneous alloys follow the same general rules. The only new viewpoint is that the individual phases may or may not be sensitive to stress corrosion as indicated by the above rules. In the evaluation of the corrosivity of the individual phases, both the sensitivity to stress corrosion and the purely chemical resistance have to be considered. Only with absolute chemical resistance to the corrosive medium is there no danger of stress corrosion.

If there is only a small amount of one phase, the behavior depends on the chemical resistivity and the sensitivity to stress corrosion of the minor phase. If there are about equal amounts of the two phases, the occurrence of stress corrosion is a function of various factors: the relative amounts of the two phases, the electrochemical potential difference between them, and the type of

DIGEST

corrosive medium. (L. Graf, "The Cause of the Sensitivity to Stress Corrosion of Homogeneous Alloys." *Metallforschung.* (German), Vol. 2, July/Aug. 1947, pp. 193-207; L. Graf, "On the Stress Corrosion of Heterogeneous Alloys." *Ibid,* pp. 207-212; K. Matthaes, "On the Effect of Stress on the Danger of Failure by Stress Corrosion." *Ibid,* pp. 213-225.)

Applications of Sintered Alumina

Condensed from "Metallurgia"

Sintered alumina has a number of desirable properties that suit it to a variety of applications as a structural material. All ceramic shaping processes can be applied to sintered alumina. As far as pure aluminum oxide is concerned, casting and the addition of organic plasticizers and binders are the most widely used methods. Sintered alumina bodies with a permanent bond are often difficult to cast but suitable for extrusion.

Sintered alumina is characterized by its extreme chemical inertness. Among the physical properties, the high melting point of 3720 F, the complete gas-tightness at 3090 F, the great hardness and the excellent mechanical properties which are retained at high temperatures are outstanding. Thermally, the conductivity is exceptionally high for ceramic materials while it shows a very high electrical resistance at high temperatures.

These properties make it an almost ideal material for a whole variety of products. Laboratory equipment of this ceramic stands up to chemical and thermal stresses extremely well. During the war most of the aircraft spark plugs used sintered alumina as the insulating material. It is also used as thread guides in the textile industry, as dies for wire drawing, for ceramic gages, mortars, stamps, grinding balls, high temperature furnace linings and sand blasting nozzles.

Despite considerable development work, sintered alumina tools and gas turbine blades appear to be still in the laboratory stage. (F. Singer & H. Thurnauer. *Metallurgia* (British), Vol. 36, Sept. 1947, pp. 237-242; Oct., pp. 313-315.)

A New Nickel-Bearing Copper

Condensed from "Metal Industry"

A new nickel-bearing copper, called E.R.M. 3A, has been developed by Enfield Rolling Mills, Ltd. in England. The nominal composition is 1 nickel, 0.2 phosphorus, 0.2% sulfur, balance H.C. copper. This alloy combines a high conductivity copper with strength approximating gun metal, the free machinability of brass, the ability to harden other than by cold work, the maintenance of hardness at elevated temperatures, and resistance to corrosion. Its outstanding feature is age hardenability.

The heat treatment, which is independent of any cold work, is done by rapidly cooling from 1470 to 1560 F, then aging at about 930 F for 30 min. The effect of this treatment is shown in the following nominal properties:

	Tensile Strength, Psi.	Yield Strength, Psi.	Elongation % in 2 In.	Vickers Hardness
Sand castings	30,800	26,000	16	118
Hot forgings	40,000	10,000	45	50-60
Hot forgings, tempered	60,000	40,000	28	120
Hot forged, cold worked and tempered, hard drawn	75,000	50,000	18	150
and tempered rod, bar and strip	85,000	60,000	12	180

The increased hardness is maintained after heating up to 930 F. Combined aging and cold working give up to 180 Vickers, as indicated. The cold work can be done either before or after aging.

This alloy is available in hard drawn and tempered rod, bar, strip and section, extrusions, stampings, forgings and sand castings. Typical electrical products being made of it are contacts, contact blocks, switch parts, commutators, bus-bar connections and collector rings. Welding applications include cutting nozzles, flash butt dies, holders, arms, tables and adapters. The alloy is also being used for bulkhead studs, nuts and bolts. (*Metal Ind.* (British), Vol. 71, Oct. 10, 1947, p. 301.)

Surface Effects During the Annealing of 70:30 Brass

Condensed from "Journal of the Institute of Metals"

Copper-zinc alloys, particularly those with more than 15% zinc, are difficult to anneal fully without surface discoloration. The difficulties are associated mainly with their marked susceptibility to oxidation and staining and to the comparatively high vapor pressure of zinc at normal annealing temperatures. Probably the main difficulty is the loss of zinc by evaporation, which attains an appreciable rate at temperatures over 840 F. The zinc loss results in the enrichment of the surface of the alloy in copper, destroying the normal brass color and giving rise to superficial roughening and etching.

Cracked ammonia is the only industrial controlled atmosphere that meets the requirements of a protective atmosphere free from oxidizing and sulfurous gases. Annealing under a pressure of cracked ammonia restricts the loss of zinc from brass but does not prevent surface oxidation. The source of the oxidation is primarily the gases evolved from the brass itself.

Annealing in vacuum removes this source of staining, but the metal surface is etched due to an appreciable loss of zinc from the surface, which assumes a coppery appearance. Annealing in cracked ammonia results in some zinc loss with surface staining, but even at 1110 F the brass does not lose completely its yellow color. By a combination of a vacuum treatment followed by an anneal at a higher temperature in a static atmosphere of cracked ammonia, specimens have been produced free from surface staining and having an etched appearance.

The final treatment in the static atmosphere permits the zinc to diffuse to the surface and replace that previously lost during the vacuum treatment. The alloy thus tends to regain at the surface the original composition and color. This double process has been successfully applied to the bright annealing of small coils of degreased or dry rolled strip. With material rolled in oil, an almost imperceptible stain remains at the center of the strip. This has been overcome by separating the individual coil turns by brass wire spacers.

With increasing density of the annealing atmosphere, the rate of loss of zinc decreases. An atmosphere produced from hydrogen saturated with methanol vapor has given the most encouraging results from the point of view of nonoxidation and restriction of zinc evaporation. It is considered that a combination of vacuum treatment and a final anneal in this type of atmosphere may provide a process for the bright annealing of brass on a commercial scale. (I. Jenkins. *J. Inst. Metals* (British), Vol. 73, Part II, 1946/7, pp. 641-665.)

A New Micro-Hardness Tester

Condensed from "Metallurgia"

A new micro-sclerometer has been designed for use on metallurgical microscopes. Among its applications are determining the hardness variation in the surface layer of a case hardened steel, the effect of load on the hardness number of aluminum, the hardness of iron electro-deposited under different experimental conditions, and the micro-hardness of bainite and ferrite in the same metallographic section.

The tester is so compact that it can be interchanged with the objective of most microscopes. After a suitable area is chosen

visually, the microscope objective is replaced by the micro-sclerometer without displacing the specimen. The microscope stage is then lowered into the spring-loaded diamond indenter. The axial displacement of the indenter, which is measured by optical means, is indicative of the load exerted. After raising the stage, the micro-sclerometer is replaced by a high-power objective so the dimensions of the impression, which are a function of the hardness, can be measured.

The micro-sclerometer has five springs for loads of 10 to 1000 grams so very high sensitivity is obtained. The errors in the hardness number will nearly always be caused in the measurement of the impression diagonals. Under the best conditions, the accuracy in micro-hardness will be 1.5%, unless the impression is too small to be measured accurately. The Vickers hardness number so obtained is generally independent of the applied load between 5 and 120 kg.

A knowledge of the Meyer number for a specific material permits the comparison of the Vickers hardness numbers obtained under different loads within the range of the apparatus. (M. R. Girschig. *Metallurgia* (British), Vol. 36, Sept. 1947, pp. 269-273; as abstracted from *Rev. Métallurgie*, Vol. 43, Mar.-Apr. 1946, pp. 95-112.)

An Atmosphere for Heat Treatment Without Decarburization

Condensed from "Metallurgia"

A new method of producing and maintaining a suitable protective atmosphere for heat treating steels without decarburization has been developed. A new type burner is used that employs ordinary paraffin or kerosene as its fuel. The atmosphere producing unit is extremely simple. The fuel is passed under pressure to the vaporizing burner fitted under the sill-brick of the furnace. In the burner the fuel is vaporized and the vapor mixed with the correct amount of air before combustion. The products of combustion, which are at a very high temperature, pass through a slot in a specially designed sill-brick and into the furnace. After passing around the work in the furnace, the atmosphere leaves the furnace through a flue in the back wall.

The fuel is easily obtainable and the consumption is very economical so that the cost of this atmosphere is low. Other advantages are simplicity of operation, low initial fuel cost and relative freedom from sulfur compounds. The unit is completely self contained and the composition of the atmosphere cannot be altered by changes in gas or air pressures.

There are two main features which contribute to the successful heat treatment of carbon steels with practical freedom from decarburization. First, the atmosphere is generated virtually in the furnace itself and the hot gases, while they are always cooled down to the furnace temperature, do not cool down to room temperature. Thus, although the combustion of the fuel is practically complete, the mixed gases are sufficiently high in carbon monoxide to suppress the decarburizing action of the carbon dioxide and the water vapor. Secondly, the burner is designed to give a high degree of turbulence to the products of combustion. This assists in rapid purging of air from the furnace and ensures a constant suppy of fresh atmosphere.

Practically every type of steel commonly used has been heat treated in this atmosphere with satisfactory results. No attempt has been made to produce a bright finish as this requires special quenching arrangements. The object was to produce a commercially acceptable finish, free from decarburization, which would be file hard and would give the desirable silvery white finish after sand blasting. There were no signs of decarburization on any of the specimens treated, and full hardness was obtained in every case. (R. A. P. Misra. *Metallurgia* (British), Vol. 36, Oct. 1947, pp. 327-330.)

Very Small Amounts of Sulfur and Oxide Inclusions in Steel

Condensed from "Revue de Métallurgie"

The quality of steel—particularly as reflected by longitudinal and transverse impact tests—is very sensitive to small variations in minor constituents such as sulfur and oxygen.

It is well known that the quality of steel improves as the sulfur content decreases down to about 0.020%. Tests were made to determine the effect of a further decrease in the sulfur. It was found that the relationship between impact and tensile strength (or hardness) varied with the sulfur content. A decrease in the sulfur content from 0.012 or 0.014% to 0.007% caused an appreciable increase in the impact value. This was particularly marked in the transverse impact properties. The quality of the heat as expressed by longitudinal and transverse impact properties is a function not only of the sulfur content but also of the number and size of the sulfide inclusions.

On the basis of the oxide inclusions, the steels were classed into three groups: (1) steels with globular silica inclusions, (2) steels with nonplastic alumina or aluminate inclusions, and (3) steels with various types of plastic inclusions. There is a clear relationship between the nature of the inclusions and the transverse impact properties with the lowest impact values corresponding to group 3 and the highest to group 1.

Fatigue tests were made on steels belonging to each of these groups with various types of fatigue specimens and various positions of the specimens relative to the rolling direction. The results were rather erratic and depended on the type of fatigue test. It was concluded, however, that the endurance limit was affected by the form of the inclusions just as is the impact but to a much less marked degree. It is believed that the impact test, particularly the transverse impact test, is the best method for evaluating the quality of steel. (M. L. Colombier. *Rev. Métallurgie* (French), Vol. 44, Jan.-Feb. 1947, pp. 47-57.)

A New Method for Making Precision Casting Molds

Condensed from a Report of the Office of Technical Services

A unique method for making sand molds and cores for precision casting of various metals was developed in Germany. The process appears to be especially important for casting small pipe fittings in steel, hitherto cast in malleable iron only.

Called the "C" process by the inventor, Johannes Croning, the method uses a molding material consisting of a dry mixture of high-grade silica sand and a plastic binder in powdered form.

The procedure for making molds from the material is simple. The half pattern, gate and runner are permanently fixed on a metal plate. A set of beveled bosses and corresponding cavities are machined on the pattern plates and these shapes, when transferred to the mold halves, serve as positioners to insure exact matching.

The pattern unit is heated to about 400 F and sprayed with a paraffin solution which provides a uniform oily film. The plate is next clamped, pattern downward, over a box containing the molding material. Then the assembly is quickly inverted. The molding material falls and covers the surface of the hot metal, softens, adjusts itself to the shape of the pattern and plate, and forms a continuous coating over the entire surface. The coating builds up to 3- to 4-mm. thickness in about 6 sec.

The pattern plate with the adhering coating is then placed in an oven at 500 F for 2 to 3 min., resulting in the conversion of the resinous material to a hard insoluble Bakelite type plastic which bonds the sand grains together. The half mold is a thin shell with enough strength and stiffness for the casting operation. Cores are made in much the same manner.

In casting, liquid metal is poured into the mold in the conventional manner. The metal is easily removed from the mold as no burning on or sticking of sand to the casting surface occurs. Cores can be removed by lightly tapping the casting.

Castings of iron, steel and aluminum made by this method in as-cast condition were found to have unusually smooth and clean surfaces. The fin around the parting line was very thin and could be easily removed. Shot blasting was unnecessary. The smallest castings show remarkably minute detail. (W. M. McCullock. PB 81284—"The C Process of Making Molds & Cores," 7 pp. Published by The Office of Tech. Services.)

Remember this Fan . . .

You don't have to baby the new Moore fans and blowers. Rugged and corrosion-resistant, you can install them and forget them. Read why!

The Moore Company of Kansas City, Mo., realized that pressure fan users were getting fed up with breakdowns and time-consuming servicing of their air-moving equipment.

So, this company decided to design a blower . . . from start to finish . . . that would give extra-long life and trouble-free performance.

In the hub of their new unit, they built a heavy-duty, direct-drive motor. This has only one moving part . . . the rotor to which the fan is attached.

The entire motor assembly is isolated by soft synthetic rubber mounts. Bearings are permanently lubricated and sealed.

But, that's not all. Moore engineers also realized that corrosion figured heavily in fan failures. Blades, guide vanes, hubs, and rims must withstand damp or steamy atmospheres, smoke, coal dust . . . or even acid fumes.

The one metal Moore found to lick all these conditions was the INCO *Nickel Alloy . . . MONEL*.*

In addition to its corrosion resistance, Monel also fights abrasion. And, it's as strong as structural steel. Thus, the curved and formed fan sections are thinner and far lighter than cast parts . . . without sacrificing strength.

Moore direct-drive ventilating fans and pressure blowers are available from 36" to 96" in diameter, with capacities up to 125,000 cu. ft. per minute. Other Moore fans range up to 24 ft. in diameter, capacities of more than 1,000,000 C.F.M. Made of tough, corrosion-resistant Monel, they are used today by power stations, foundries, oil refineries, textile mills, and many other industrial plants. For detailed information, address The Moore Company, 544 Westport Road, Kansas City 2, Missouri.

* * * *

The above is another example of how strong, long-lasting INCO Nickel Alloys are serving modern power plants. Other applications include preheater tubing, valves, pump parts, fittings, and gaskets.

If *you* are looking for one metal to solve a tough combination of problems, find out more about the family of INCO Nickel Alloys. Full technical information and assistance are yours for the asking.

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MATERIALS & METHODS **Engineering File Facts**

NUMBER 154
January, 1948

MATERIALS: Plywoods

Technical Plywoods

With the improvement in manufacturing techniques, the importance of technical plywoods as engineering materials has increased tremendously. A summary of the commonly used engineering types of plywoods is presented below; the numerous, and important, architectural qualities of plywoods are omitted from this Engineering File Fact.

Construction

Plywood is usually a combination of three or more layers of veneer glued together with the direction of the grain in each lamination, or ply, running at right angles to that of those on each side of it. (If the adjacent layers have parallel grain directions, the product is called laminated wood, discussion of which is not included in this File Fact.) Because of this construction, plywood possesses similar strength properties along its length and width. Uniformity, great dimensional stability and resistance to splitting are distinctive properties of this material.

Plywoods differ in four important respects: material used; quality and finish of surface panels; the bonding agent; and the manufacturing techniques and their effects on the resulting physical properties of the plywood.

The bond not only influences the mechanical properties of the plywood, but it determines the ability of the laminate to withstand the effects of moisture. Plywoods intended to be used where moisture is present are variously designated as having a "Fully Waterproof Bond" or "Waterproof Glue," or as being "Marine" or "Exterior" quality.

The types of construction and the materials used in common technical plywoods are listed in Tables 2 and 3.

Commercial Grades, Finishes and Sizes

Table 1 summarizes the standard sizes in which technical plywoods are generally sold. Omitting the architecturally important decorative finishes, the common grades and finishes are tabulated in Table 4.

Table 1—Summary of Standard Sizes of Technical Plywoods

Type and Grade of Plywood		Standard Sizes, In.			Size Tolerances, In.
		Width	Length	Thickness	
Western Hemlock	So2S, So1S	24, 30, 36, 48	60, 72, 84, 96, 108, 120, 144	1/8, 3/16, 1/4, 3/8, (3-ply, sanded 2 sides); 1/2, 5/8, 3/4 (5-ply, sanded 2 sides)	±1/64 on thickness of sanded panels ±1/32 on thickness of unsanded panels
	Sheathing	48	96	5/16, 3/8 (3-ply, unsanded); 1/2, 5/8 (3- or 5-ply, unsanded)	±1/32 on length and/or width of panels Panels must be square within ±⅛
	Industrial	Up to 48	Up to 96	1/4, 5/16, 3/8 (3-ply, unsanded); 1/2, 9/16, 5/8, 11/16, 3/4, 7/8 (5-ply, unsanded); 7/8 (7-ply, unsanded)	——
Hardwood		24, 30, 36, 42, 48	48, 60, 72, 84, 96	1/8, 3/16, 1/4, 5/16, 3/8, 1/2, 5/8, 3/4, 13/16, 7/8, 1	±1/32 on thickness of unsanded panels +0 —1/32 on thickness of sanded panels ±1/32 on length and/or width of panels Panels must be square within ±1/16 on short dimension
Douglas Fir	So2S, So1S	24, 30, 36, 48	60, 72, 84, 96	3/16, 1/4, 3/8 (3-ply, sanded 2 sides): 1/2, 5/8, 3/4 (5-ply, sanded 2 sides)	±1/64 on thickness of sanded panels ±1/32 on thickness of unsanded panels
	Sheathing	36, 48	96	5/16, 3/8 (3-ply, unsanded); 1/2, 5/8 (3- or 5-ply, unsanded)	±1/32 on length and/or width of panels Panels must be square within ±⅛
	Industrial	36, 48	60, 72, 84, 96	1/4, 5/16, 3/8 (3-ply, unsanded); 1/2, 9/16, 5/8, 11/16, 3/4, 7/8 (5-ply, unsanded); 7/8 (7-ply, unsanded)	——
	Exterior	From 12, increasing by 2, to 30; also 36, 42, 48	48, 60, 72, 84, 96	3/16 (3-ply, sanded 2 sides), increasing by 16ths to 13/16 (7-ply, sanded 2 sides)	——
	Marine	Up to 96[1] Up to 48	Up to 80 ft[1] Up to 96	Standard sizes as above and 1½, 2, 3, 4, up to 7 (sanded 2 sides)	On thicknesses over 2, the tolerance is ±1/16
Metal Coated	Aluminum	30, 36, 42, 60	84, 88, 96, 108, 120, 144	1/8 to 1¼ by 8ths	——
	Zinc coated steel	30, 36, 42, 48	84, 96, 108, 120, 144	——	——
	Stainless steel	30, 36, 42, 48	84, 96, 108, 120	——	——

[1] Special.

(Continued on page 113)

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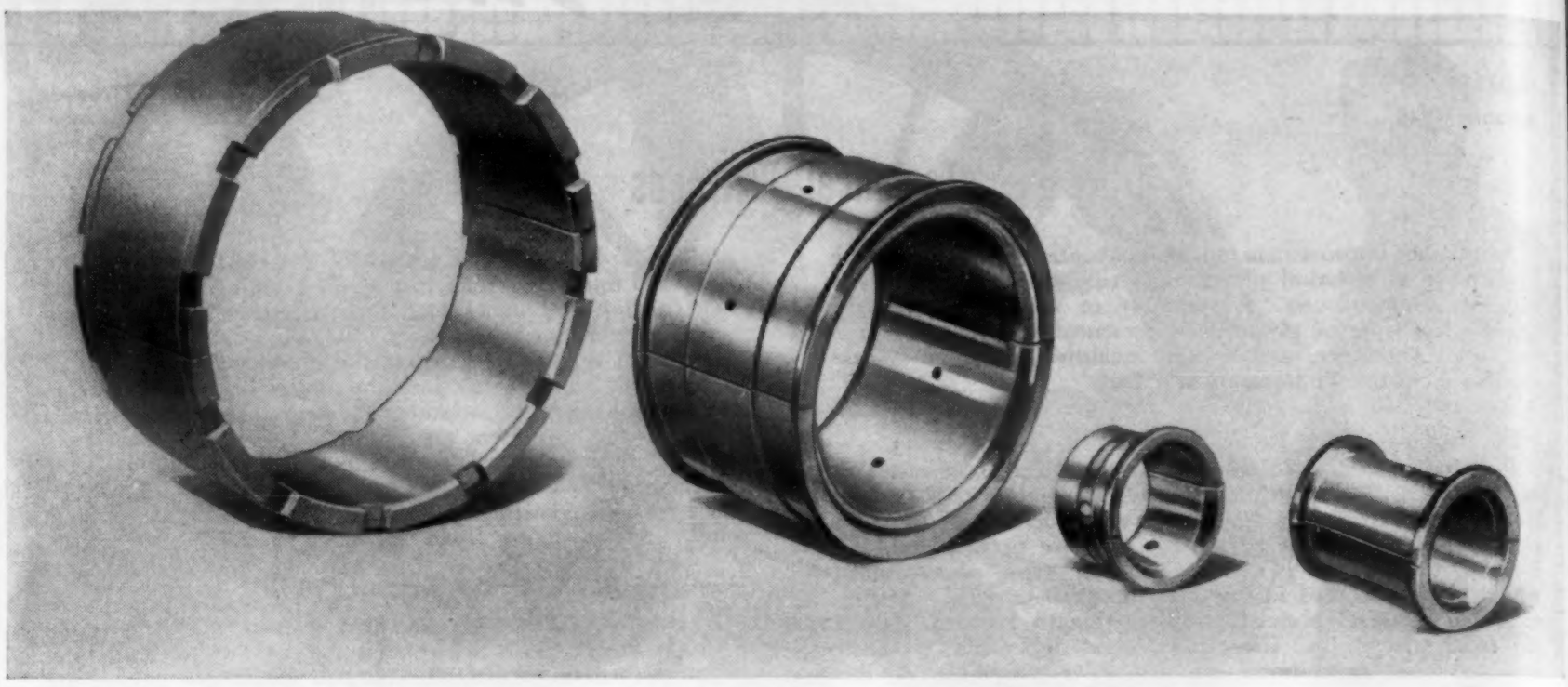

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Table 2—Materials Used in the Making of Technical Plywoods

Natural Veneer Materials	Western hemlock (kiln-dried) includes Noble and commercial white firs; Douglas fir may be used for the cores and crossbands of Western hemlock plywood; veneers 1/12-3/16-in. thick are used in the making of plywoods ¼-in. and greater in thickness
	Hardwood plywoods are composed of laminations made from the following woods:

High Density Woods	Medium Density Woods	Low Density Woods
Ash, American white	Ash, black	Basswood, American
Beech, American	Cherry, black	Chestnut, American
Birch, yellow, sweet	Elm, American (white or gray)	Cottonwood, eastern, black
Elm, rock	Hackberry	Poplar, yellow
Maple, black (hard)	Magnolia	Willow, black
Maple, sugar (hard)	Mahogany, American	
Oak, commercial, red	Mahogany, African	
Oak, commercial, white	Maple, red (soft)	
Pecan, commercial	Maple, silver (soft)	
	Sweet gum	
	Sycamore	
	Tupelo, water, black	
	Walnut, American	
	Prima Vera	
	New Guinea wood	
	Paldao	
	Oriental wood	

	Douglas Fir plywood is made of laminations of Douglas fir
Densified (Natural) Veneer Materials	Natural wood veneers are compressed (under heat) producing a very dense material of superior strength and machinability; these densified laminations can be used for facing the plywood, or as cores that are faced with natural density veneers
Processed Wood Veneers	For greater dimensional stability, densified veneers (and some natural density veneers) can be impregnated with phenolic resin prior to assembly
Metals Used for Surfacing Plywoods	Sheets of the following metals may be bonded to one or both sides of the plywood panels: Zinc-coated steel, Stainless steel, Porcelain enameled steel, Aluminum, Monel, Copper, Brass and electroplated coatings such as chromium, copper, etc.

Table 3—Construction Features of Technical Plywoods

Type of Construction	Construction Features
All Veneer[1]	Plywoods made with an odd number of layers of either natural or "densified"[1] veneer; depending upon type of lamination and grade of plywood, the maximum thickness of individual veneer layers ranges from 1/12 to 3/16 in.
Lumber Core	Lumber core faced top and bottom with sheets of veneer (an example is plywood with a balsa core to increase the thickness, and rigidity, without increasing the weight); lumber cores are ⅝-in. or greater in thickness
Composite[1]	There are a wide variety of industrial composite-type plywoods: a. Veneer, or wood, core faced top and bottom with sheets of fiber b. Laminated veneer faces (usually 3 ply) over hollow core c. Densified veneer laminations impregnated with phenolic resins prior to assembly d. A non-wood core (such as asbestos or Masonite) faced top and bottom with veneer e. Metal coated plywood; sheet metal may be bonded to one or both sides of the panel

[1] *For detailed listing of the materials used in the construction of industrial plywoods, see Table 2.*

Table 4—Commercial Grades of Plywoods

Grade Designation	Remarks
Sound Two Sides (So2S)	Well matched surface veneers free from blemishes; sanded on both faces
Sound One Side (So1S)	One side must be as above, the reverse can have certain imperfections; sanded on both faces
Sheathing	Unsanded material; one face may contain minor defects and blemishes; the other defects that do not seriously affect the strength or serviceability of the panel
Concrete Form Panels	Both sides similar to reverse side of above
Industrial	Unsanded material (touch sanded only); faces may contain minor defects and patches; strength and solid surfaces rather than appearance are of prime importance
Exterior	Must be sound mechanically and capable of withstanding all types of weather conditions
Marine	Must withstand both salt and fresh water; construction is more critical than in the Exterior Grade; appearance not of prime importance

Compiled from data furnished by the following organizations:

Harkelite Mfg. Corp., Grand Rapids, Mich.
M & M Wood Working Co., Kenton Station, Portland, Ore.
Technical Ply-Woods, Chicago, Ill.
U. S. Plywood Corp., New York, N. Y.
U. S. Dept. of Agriculture, Forest Service, Forest Products Lab., Madison, Wisc.
U. S. Dept. of Commerce, National Bur. of Standards, (Commercial Standards CS45-45, Douglas Fir Plywood; CS35-47, Hardwood Plywood; and CS112-45, Western Hemlock Plywood).

Prepared by Robert S. Burpo, Jr.

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High Torsional Strength
High Fatigue Resistance
Low Deflection
Low Permanent Set
Low Elastic Drift
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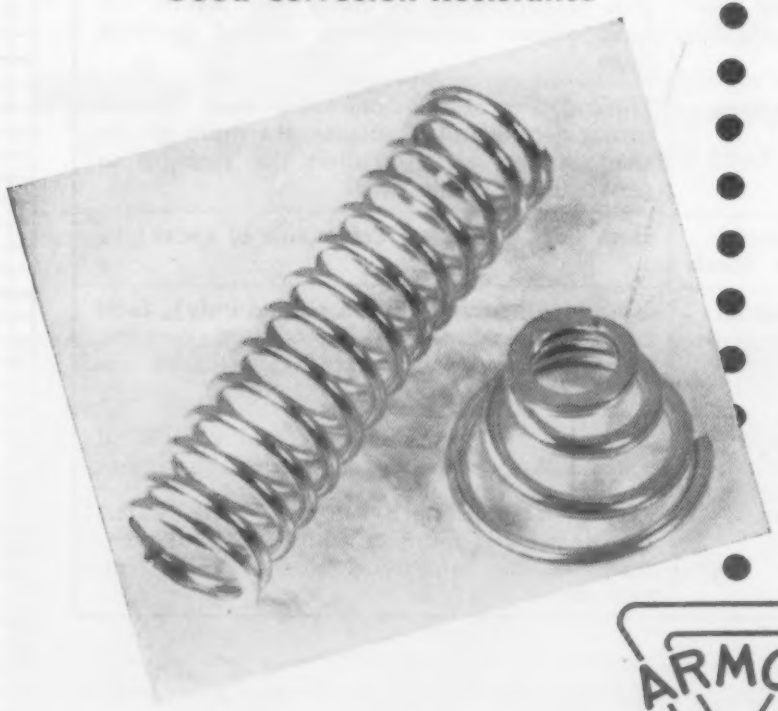


Springs made of ARMCO Special 16-2 Wire.

If you can use stainless steel spring wire to advantage you'll want to know about the many excellent properties of new ARMCO Special 16-2 Spring Wire.

Special mill processing gives this new spring wire exceptionally high elastic properties and low drift. Its elasticity is indicated by these data:

Wire Diameter, Inch	Proportional Limit in Tension 1000 psi
.0365	264
.060	206
.291	170

Low Permanent Set

Another outstanding characteristic of ARMCO Special 16-2 Spring Wire is its low permanent set at elevated temperatures. How well this special wire maintains load-carrying properties at elevated temperatures is revealed in these comparative tables:

Stress 40,000 psi	Temperature 650° F.	
Material	Permanent Set After 812 Hours	Permanent Set After 600 More Hours
Music Wire	40.0%	No Data
18-8 Stainless Steel	14.0	19.0%
ARMCO Special 16-2	6.4	6.4

ARMCO Special 16-2 Spring Wire is supplied in coils or straight lengths, with a standard cold-drawn finish or with a lead coat for use on automatic coiling machines. Write to the address listed below for your free copy of the descriptive booklet "This New Spring Wire Gives Your Products 8 Big Advantages."

Other ARMCO Stainless Steels available for early delivery include a wide variety of sheets, strip, plates, bars and wire. Just address The American Rolling Mill Company, 113 Curtis Street, Middletown, Ohio. Export: The Armco International Corporation.

ARMCO

ARMCO Stainless Steel Wire

New Materials and Equipment

Metallizing Gun for Production Work

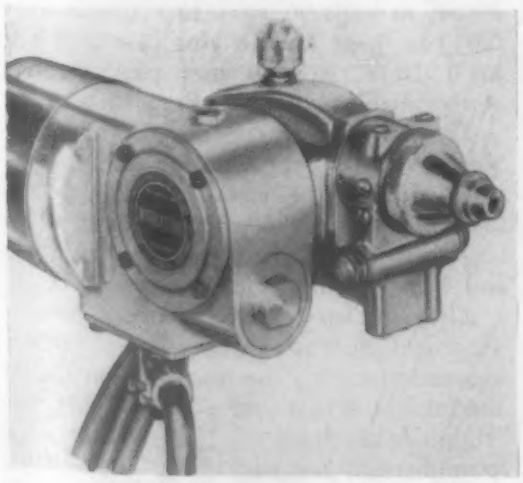
A new type metallizing gun powered by an electric motor has been announced by the *Metallizing Co. of America,* 1330 W. Congress St., Chicago 7.

The unit, called the Mogulectric, is for production-line spraying or other types of spraying where high speeds are essential. By using different combinations of gearing, different spraying speeds can be obtained to spray any of the metals used in the metallizing industry. Through the use of an electric drive, air requirements are materially reduced and turbine adjustments are eliminated.

The unit is powered with a 1/20-h.p. constant speed induction motor. The wire will not feed too fast nor will it feed too slow, and the only adjustments required are gas and air. At the front end of the motor is the gear reduction which runs in a bath of fluid grease enclosed in an aluminum housing.

The drive component carrying the feed rolls and combustion unit can be swung around from a horizontal spraying position so the gun can spray vertically, up or down or at any angle if desired.

The gas head is a pressure-tight bronze casting. This has a removable nozzle seat which can be replaced if the seat becomes damaged through careless handling. The wire nozzles are made of copper with a hardened steel insert. There is no adjustment to the air cap, as this is held in fixed position.



This metal spray gun is electric powered and is capable of high-speed spraying.

New Control Permits Aluminum Spot Welding

A new sequence control capable of converting ordinary resistance welders to the production of spot welds in sheet aluminum and most nonferrous metals has been announced by *Acro Welder Mfg. Co.,* 1825 W. St. Paul Ave., Milwaukee 3, Wis.

The new unit can be used with any type air-operated spot welder of sufficient capacity. It is a refinement of the well-known forge-delay principle. Easily installed and operated, it works in conjunction with standard transformer-type a. c. air-operated welding machines, timers and contactors. The control's calibrated dial-type timer is not affected by any line voltage change.

The sequence control is said to produce good spot-welds in a variety of sheet aluminum alloys, including the aluminum utility sheet.

Only two sizes of the sequence control are needed to fit into the entire range of air-operated spot welders. Model AP-45 attaches to 100-kva. capacity machines or less, while Model AP-65 is built for machines with rated capacities higher than 100-kva. Either unit will operate with any spot welder having solenoid-operated air valve and modern timer and contactor, and with various combinations of electronic and mechanical controls.

Derodder for Metal Tubing Manufacture

In mandrel drawing of metal tubing after the tube and mandrel have passed through the die, it is necessary to relieve the tubing so that the mandrel can be readily removed. For this purpose, *Glengarry Machine Works,* Bay Shore, N. Y., offers a new high-speed derodder, or mandrel reliever.

This machine, operating at speeds up to 120 ft. per min., will handle ferrous tubing in sizes up to 7/8 in. in dia. with wall thicknesses up to 0.065, and nonferrous tubing in dia. up to 1 in.

The transmission runs in oil. The machine has simple micrometer adjustments, which when once set, require no further attention. For light work, especially on irregular lengths of tubing, the tie bar can be quickly removed.

● A new silver soldering outfit introduced by the *American Products Corp.,* 803-4 Lowell Bldg., Chicago 5, includes an improved type alcohol torch, fuel, heat retaining chamber, accessories, instructions for use, and a silver solder supply kit including a tube of flux paste and 100-in. assorted sizes silver solder wire and 1-in. width strip sheet. It is handy for a variety of silver alloy brazing jobs.

Electroplating Wire That Can Be Formed

A new type of electroplated and drawn wire that can be bent, swaged, hammered, woven or twisted without flaking is now being produced by *Kenmore Metals Corp.*, Warren, Pa. The new wire product has a wide range of manufacturing applications in radio tubes, incandescent and fluorescent lamps, electrical devices and appliances, jewelry, and wire goods.

The wire, caller "Fernicklon," is made from ¼-in. dia. metal rods that are first electroplated continuously, then cold-drawn down to diameters as fine as 0.0038 in. One in. of ¼-in. plated rod may produce as much as 100,000 ft. of plated wire, permitting it to be ordered in continuous sections of almost any length.

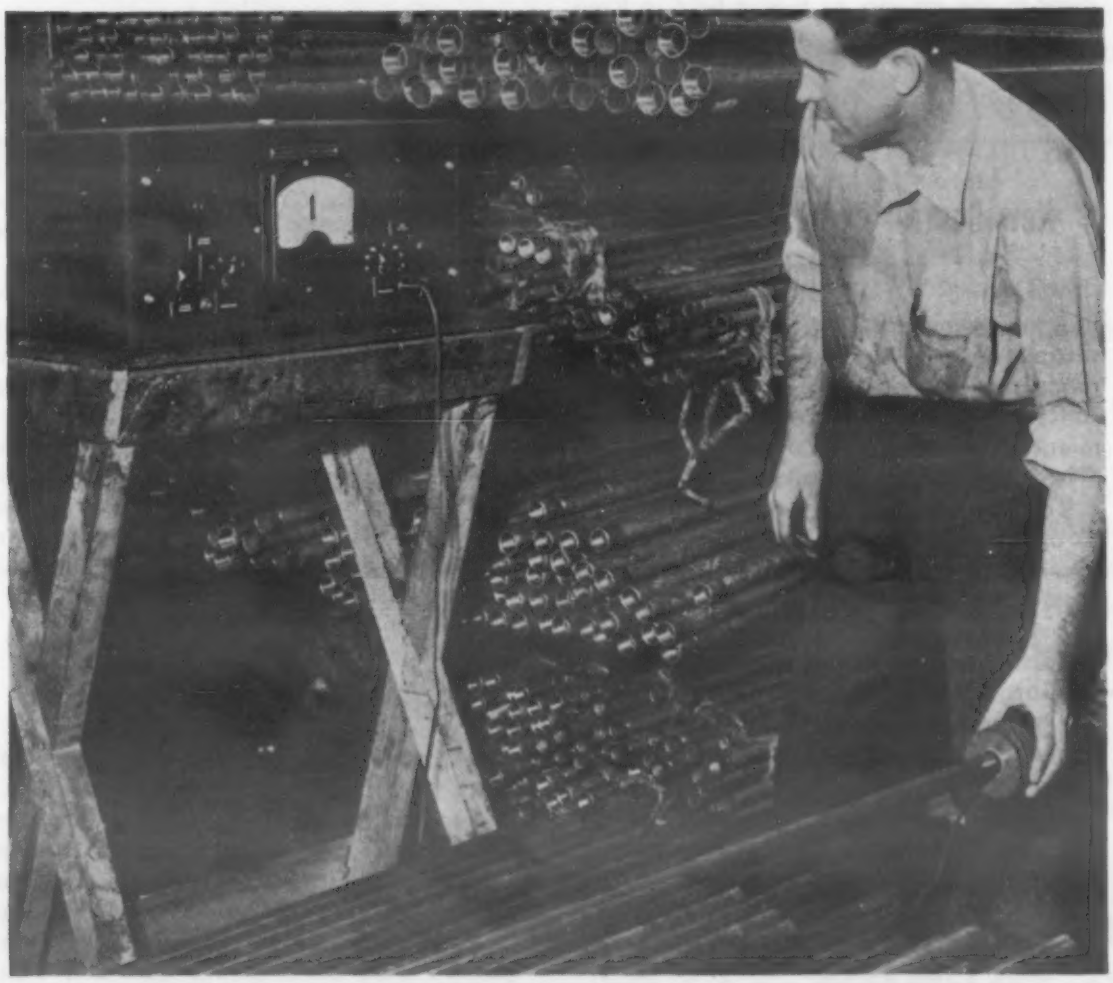
Initial production includes steel wire with nickel, copper wire or silver for radio tubes and lamps, household utensils, and tinsel wire. Die polish or satin finishes are available. Because of its surface finish and the bond between its constituent metals, the wire can be subjected to the severest climatic conditions when an anti-corrosive coating metal is used. It can also be welded to form a product without destroying the coating at the point of the weld.

Metals Comparator Separates Annealed from Unannealed Parts

A new metals comparator has been introduced by *General Electric Co.*, Schenectady 5, N. Y., for providing a quick, non-destructive comparison of either magnetic or non-magnetic metal parts with a standard. Parts appearing alike but differing in composition can be separated with the new instrument. It has been used to differentiate between annealed and unannealed steel bars, and also to sort finished metal parts that possess different compositions or heat treatments.

The metals comparator employs a balancing network and indicating instrument mounted in a steel cabinet to which is connected an external test coil. In operation, a reference specimen for the group of specimens being compared is first placed in the test coil and adjustment made to secure the initial balance. This is indicated by a zero reading on the indicating instrument.

After the reference specimen has been removed, the parts to be tested are inserted briefly in the coil one by one. When tolerances have been established, specimens can be accepted or rejected on the basis of the dial reading. As many as 1500 small parts can be tested in an hour.



The metal comparator being used to sort rods in stock room.

Casting Machine Reduces Manual Operations

A permanent mold casting machine that is designed to eliminate a number of manual operations is being manufactured by the *Standard Machinery Co.*, Grand Rapids 4, Mich. This machine incorporates four main castings, consisting of a bed, moving platen, stationary platen and a knock-out platen.

The machine eliminates the need for built-in operating mechanisms in individual molds. The moving platen is equipped with two adjustable tapered center guide gibs and also has adjustable tapered hold-down gibs which maintain its squareness with the bed under full operating pressures.

The machine is provided with hydraulic shock absorbers which permit a cushioning of both the opening and closing stroke. An adjustable knock-out bar and plate permit the incorporation of knock-out pins in molds for the easy ejection of finished castings. The last 3 in. of knock-out stroke are cushioned by means of springs mounted on the knock-out platen.

The standard machine is equipped with two 6-in. air cylinders providing 18 in. of stroke. Provision is made so that six more inches of closed die space over the standard 10 in. can be obtained.

● A new line of metal cleaners has been developed by the *Parker Rust Proof Co.*, Detroit 11. Known as Parco Cleaners, they come in three classes for steel, zinc and aluminum, including emulsion types, acid types, and alkaline types. The cleaners are formulated to make hard water suitable for cleaning, to rapidly remove soil from metal surfaces, to condition them for Bonderite coatings, and to remove rust and grease prior to painting.

Preplated Metal Available in New Pattern

A new preplated metal pattern, Crimp Metal, in coils in steel base metals up to 0.015-in. gage and in zinc base metals up to 0.018-in. gage is now available from *American Nickeloid Co.*, Peru, Ill.

The new pattern consists of a round embossing—raised or depressed—on the polished side of the metal, running parallel to the length of the coil. Embossed or debossed, the pattern makes a striking design and increases the rigidity of the metal.

Also, by varying the distance between the round embossings, a variety of interesting variations on the basic design can be obtained at a cost just a little higher than bright finish metals. The new metal is recommended for packaging, display, trim and structural use—wherever bright metal will increase beauty and utility.

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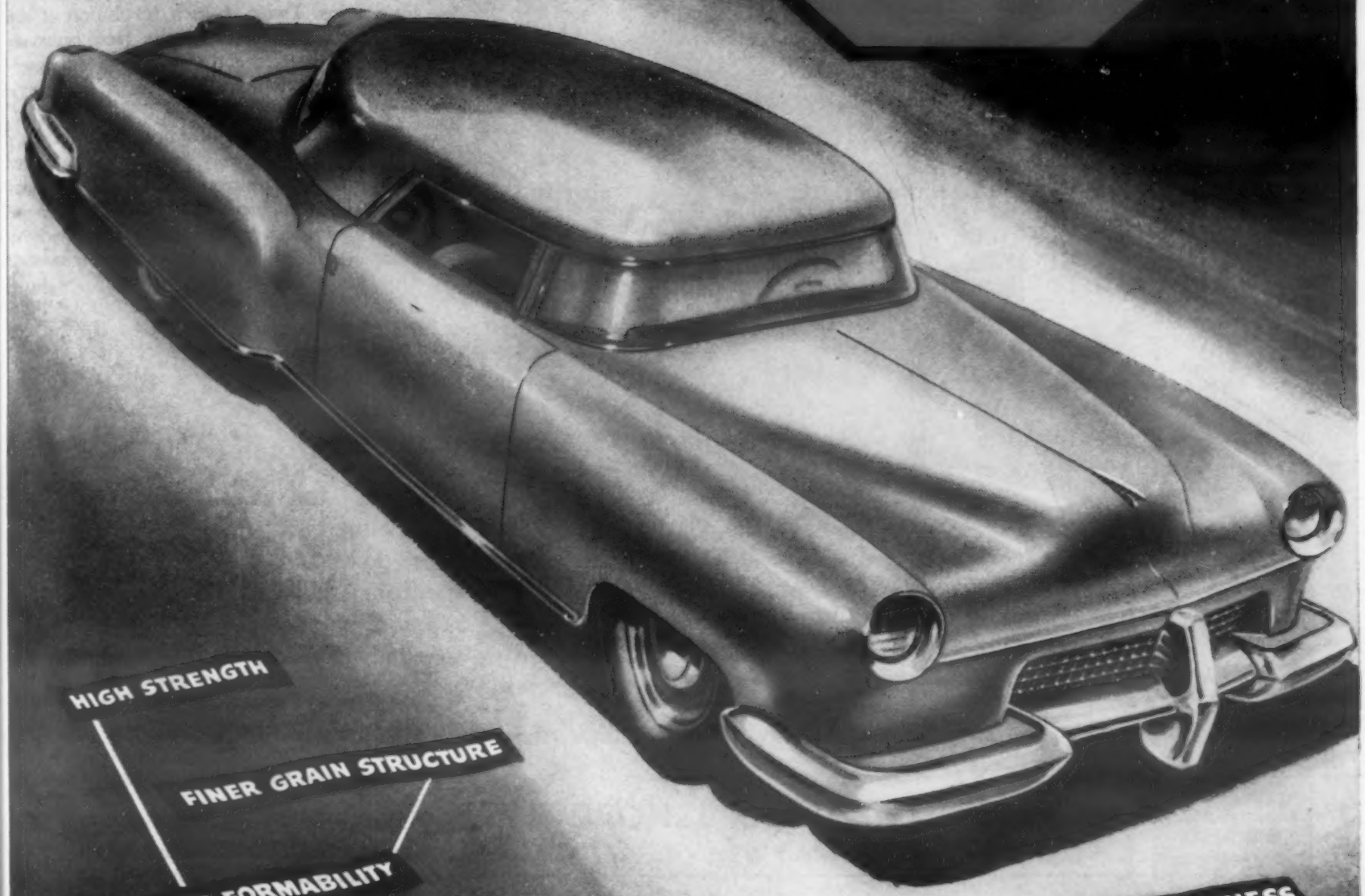

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GOOD FORMABILITY

GREAT IMPACT-TOUGHNESS

EXCELLENT WELDABILITY

HIGH CORROSION-RESISTANCE

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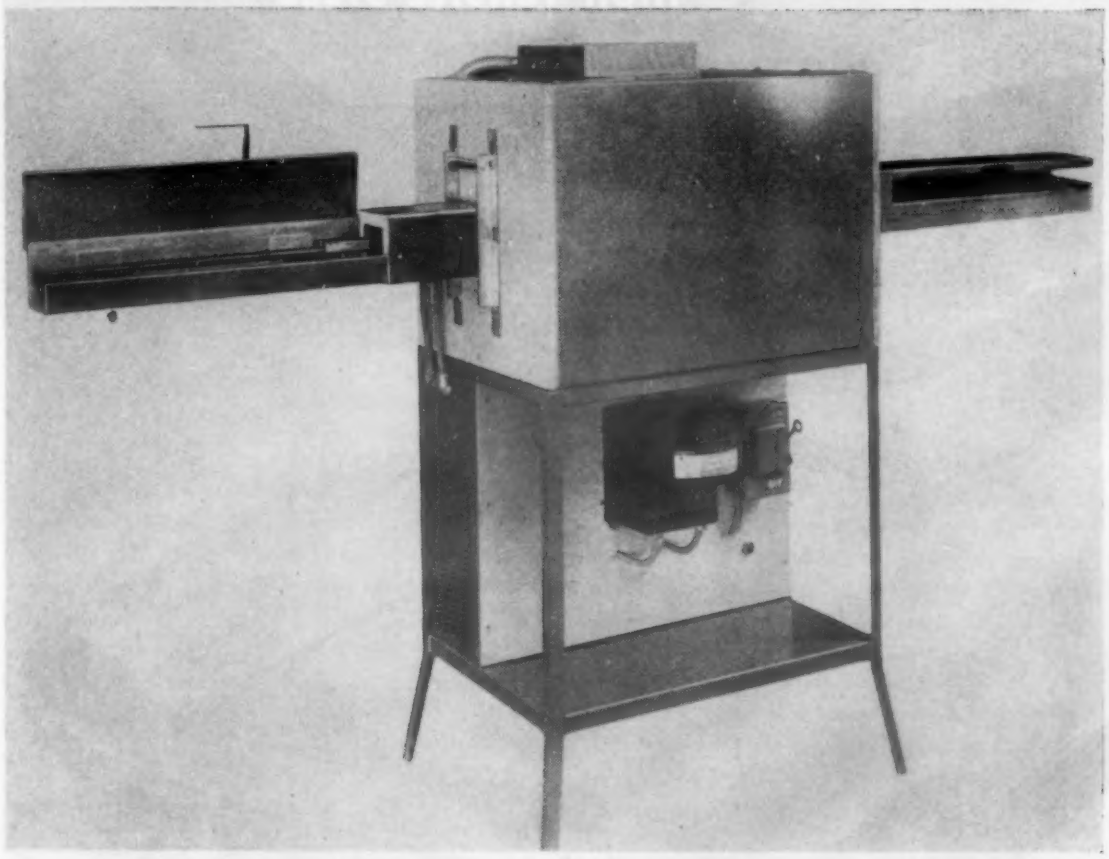
Tunnel Kiln for Heat Treating Small Parts

A new tunnel kiln for small batch production work, firing of ceramic parts, and heat treating of small parts on a production basis has just been announced by *K. H. Huppert Co.*, 6830 Cottage Grove Ave., Chicago 37. It features an electric heating element providing a maximum temperature of 2200 F.

The kiln is the pusher type, with small refractory trays being pushed through the inside of the 33-in. firing chamber by means of a variable speed drive. The firing zone is actually 10 in. long, and the size of the tray is 2⅜ in. by 3¾ in. Pusher mechanism as well as provision for loading and unloading is self-contained.

Constructed of No. 14 gage steel, the unit's weight is 700 lb., and it comes equipped with automatic temperature control, fused switch box and step-down power transformer. The kiln operates on single phase, 110 or 220 v., a.c., and has a current consumption of 2 kw. The overall-dimensions are 102 in. long and 62 in. high by 24 in. wide. The basic principles of this kiln can be applied to larger construction.



This kiln is suited for experimental or testing work on a small production basis.

500-Ton Press for Forming Has Two Speeds

A new 500-ton press with unusually long bed is being manufactured by the *Cleveland Crane & Engineering Co.*, Wickliffe, Ohio, to handle larger and heavier sheets of metal.

This press, known as a Model Mo6-14, has a 20-ft. bed and ram which permits bending steel plate up to 20 ft. by ⅜ in. or 14 ft. by ½ in. Twenty-one-in. bed extensions on both ends make possible horning operations.

This is a two-speed machine which can be operated at either 7 or 20 strokes per min. It is equipped with tonnage indicators on both ends that show the loading to which the machine is subjected. A clutch knock-out mechanism disengages the clutch when the press is overloaded. The back gage, being motor-driven, is quickly and easily adjusted to proper position.

The machine is operated by a mechanical foot treadle, but when desirable, air-electric control can be provided, enabling the use of an electric foot switch which may be slid around the floor in front of the machine to any position most convenient for the press operator. This type control is especially recommended for fast production.

Screw Machine Has Harmonic Chip Breaker

A new automatic screw machine has been developed to accommodate all normal screw machine operations with the exception of thread cutting on stock up to 1-in. dia. It is manufactured by the *Standard Machine Co.*, 1542 Elmwood Ave., Providence, R. I. This machine is set up on 24-in. spindle centers; the chip breaker is designed on the principle of harmonic vibration.

The method of driving the feed camshaft eliminates the formation and clogging of long chips. Of value in working any metal or material, this chip-breaking feature is of particular importance in working plastics and other materials which tend to form long chips. Twice in each revolution of the spindle, the rotation of the feed camshaft is interrupted, thereby effecting an intermittten feed which breaks each chip as it is formed.

Actually, the motion of the camshaft does not stop entirely, but rather vibrates harmonically within an amplitude sufficient to break each chip. The tool dwells at the end of its movement while the work is made accurately cylindrical and to a smooth surface finish.

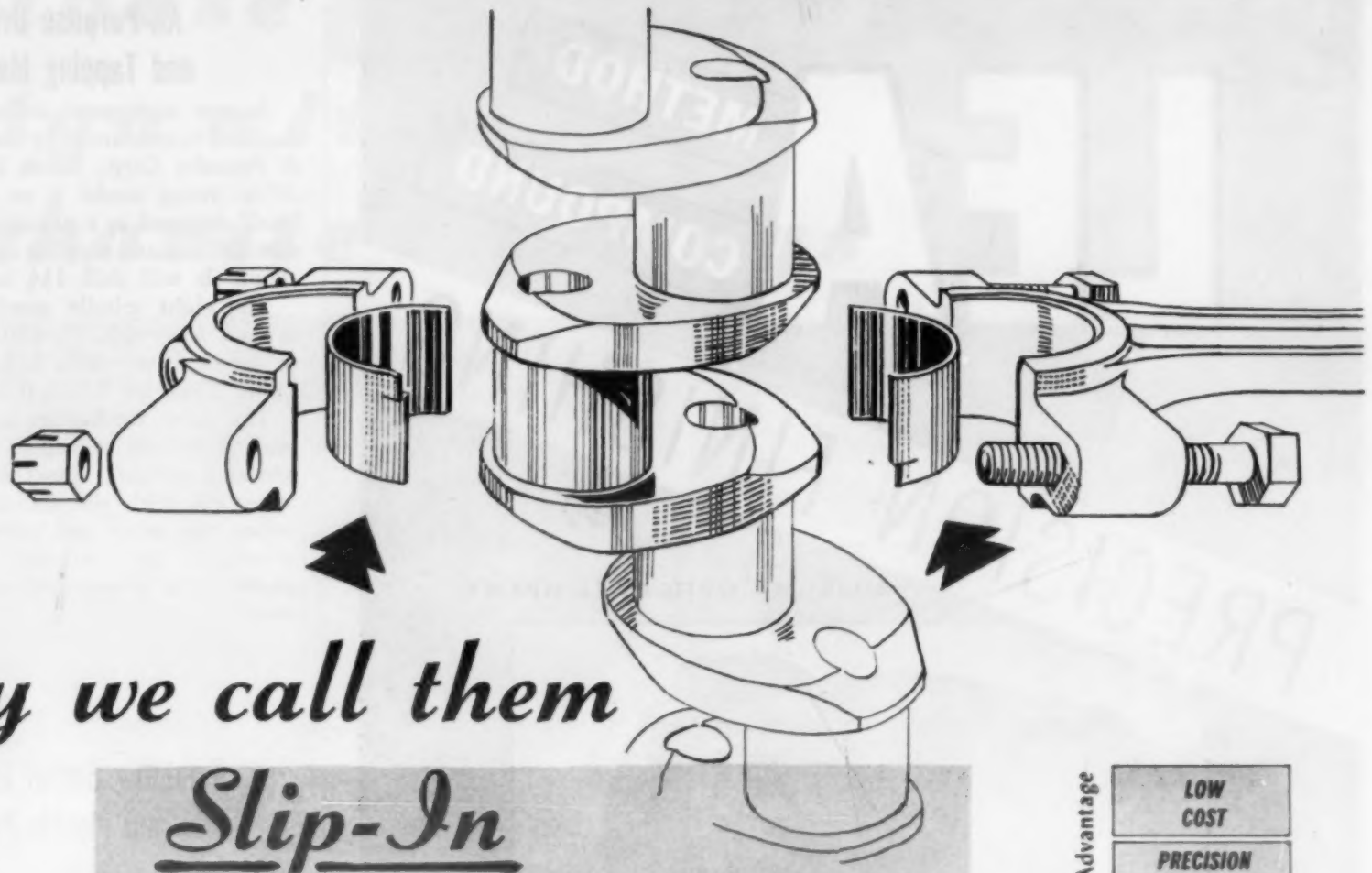
Three New Generators for Metalworking Industry

Designed to meet the demands of the metalworking industry, three new 20-kw., 450-kc. radio frequency generators are now being built by *Westinghouse Electric Corp.*, Pittsburgh 30. They consolidate generator, work table or sink, current transformers and water fittings into one unit requiring minimum floor space.

The three generators are (1) Type A, a single position unit with built-in work table and transite table top especially suited to brazing and soldering; (2) Type B, a single position unit for hardening applications with a built-in work sink, two sets of water fittings and a current transformer; and (3) Type C, two position unit suited to many soldering, brazing and hardening applications that combine a built-in work sink, two sets of coil and quench water fittings, and two current transformers with automatic transfer switch to provide two independently controlled work positions.

Stepless power output control from 0 to 20 kw. provides unusual operating flexibility in the new generators and insures uniform performance on repetitive setups.

For easy mounting of various work handling equipment, the 12-in. deep sinks are equipped with eight tapped bosses, and extra space is allowed below the sink for handling mechanisms. Built-in plug-type outlets at work positions provide 230-v. power for work handling equipment motors and for hand or foot control of both quench and heat.



Why we call them

Slip-In BEARINGS

● It is simply because they are so easy to install. Johnson Sleeve Bearings are precision made to exact specifications. This assures low cost assembly for the original equipment builders . . . quick, easy replacement by the user. Many manufacturers choose Johnson Sleeve Bearings not only because they slip right into place with a minimum of effort . . . but also because of their low original cost . . . plus their long, economical, trouble-free service.

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- LOW COST
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- EASY TO INSTALL
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LEA METHOD COMPOUND

PRECISION FINISHING *for*

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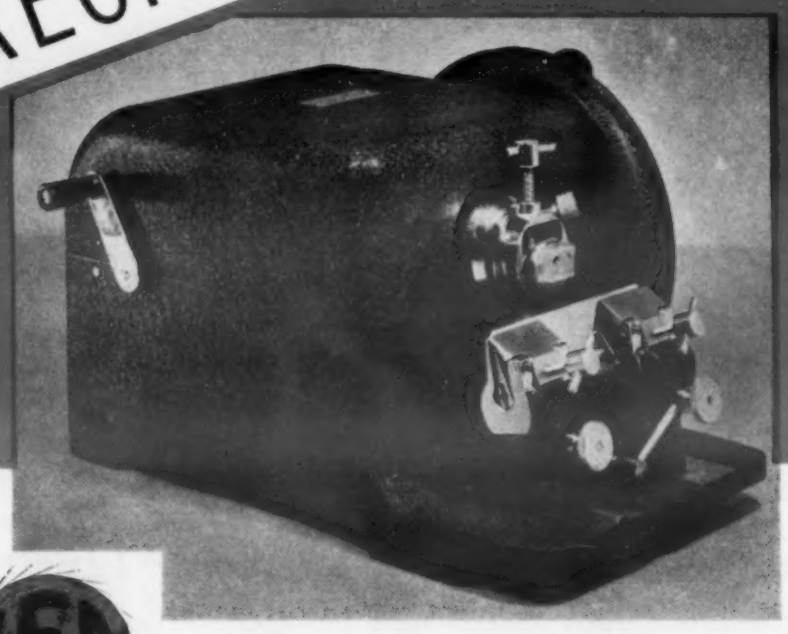

The Spencer No. 820 Precision Rotary Microtome

The American Optical Company, manufacturer of SPENCER Scientific Instruments, uses a LEA Method and LEA Compounds for finishing many parts on their well-known No. 820 Microtome. This is a precision instrument widely used in hospital and laboratory work—work that demands the utmost in precision manufacture and finish.

A LEA Method plus the proper grade of LEA Compound is outstandingly successful for high speed, close-tolerance finishing. If you are burring, polishing or buffing metal or plastic parts why not consult with our engineers. Our recommendations may cut your costs, increase your volume and improve the quality and appearance of your finished product.

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1-LM-3

All-Purpose Drilling and Tapping Machine

A new high-speed drilling and tapping machine is announced by the *Sibley Machine & Foundry Corp.*, South Bend, Ind. This 20-in. swing model is an all-purpose machine designed as a precision tool for sensitive drilling and tapping operations at high speed. It will drill 1½ in. in mild steel.

The eight spindle speeds available are: in back gear—65, 95, 150 and 225 r.p.m.; in direct drive—400, 575, 900 and 1360 r.p.m. Feeds are 0.003, 0.006 and 0.010 in.

The drive mechanism has a double ball bearing spindle assembly, with the spindle precision ground. Exact alignment of the table arm with the spindle is assured by boring the table arm after assembly with spindle of the machine. Rectangular oil groove table is furnished as standard equipment.

Tumbling Barrel for Metal and Plastic Parts

A tumbling barrel for deburring, burnishing, cleaning, polishing metal and plastic parts has been announced by *D. J. Murray Manufacturing Co.*, Wausau, Wis. Speed changes may be made while the barrel is in motion, giving a wide range of speeds to meet various operating conditions and requirements.

Dump pans are mounted on casters, and are provided with bail handle notched for crane hook. The discharge end of the pan is funnel shaped, fitting in the compartment opening to facilitate loading. Separating screens of various mesh wire can be mounted in frames to fit dump pans.

All moving parts, such as the barrel, gears, pulleys and motor, are protected with guard rail, steel enclosures, and concealed design for safety of operation.

New Dye for Phenolic Casting Resin

A new fast dye for phenolic casting resin has been announced by the *Calresin Corp.*, Culver City, Calif.

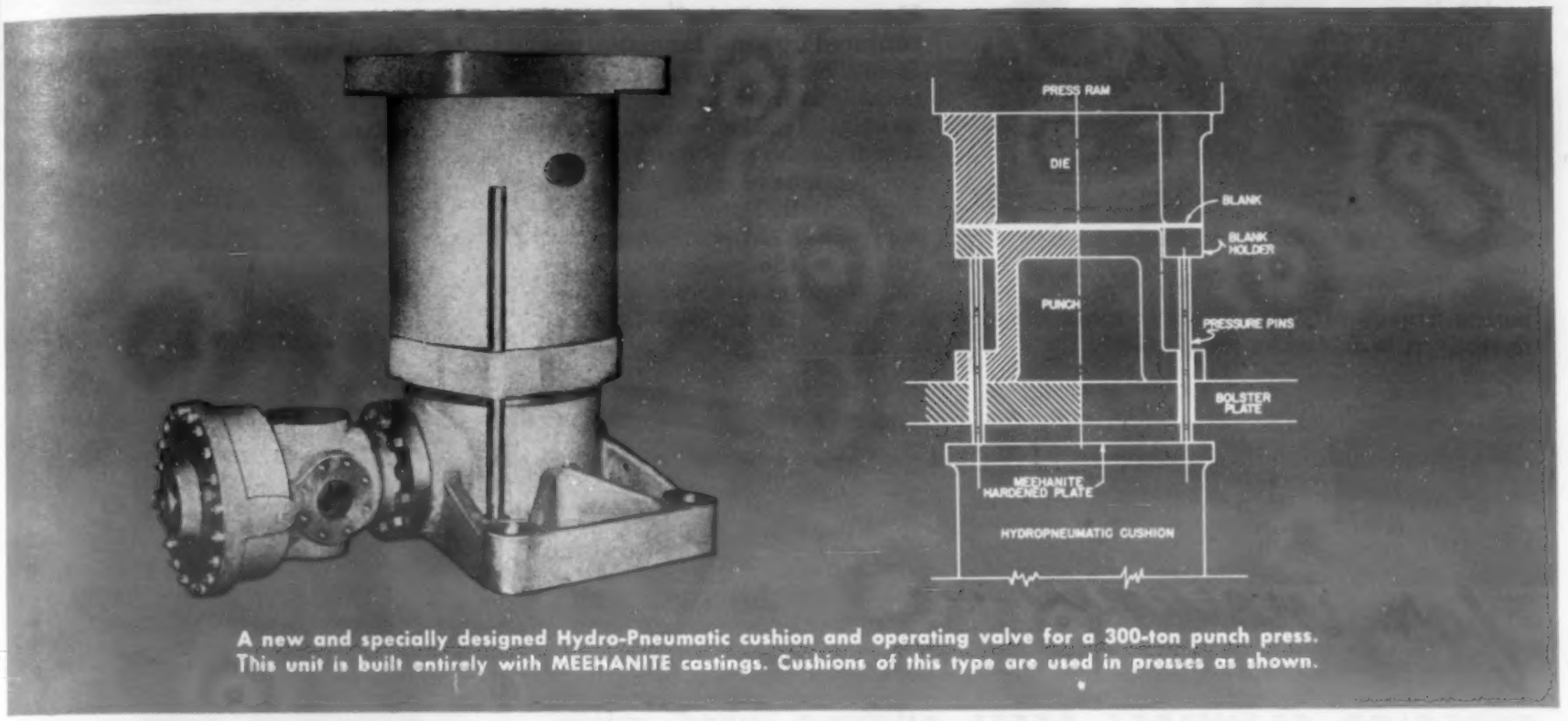
Nine basic colors with 14 shades have been developed. The dye was developed for use with the company's own phenolic casting resin, but is applicable to all such materials.

The dyes it is claimed will open up new fields for phenolic resins which up to this point have only been available in the natural color.

The curing cycle of the dye when used with Plastitool, the company's own casting resin, varies from 30 to 90 min. The percentage of the dye used varies from 1½ to 5%, depending on the lightness or brightness of shade desired.

The colors ready for delivery now are: light, medium and dark blue, vermilion and red, kelly and dark green, light and dark brown, yellow, black, gray, and ivory.

for those EXTRA *properties design with Meehanite® Castings*



A new and specially designed Hydro-Pneumatic cushion and operating valve for a 300-ton punch press. This unit is built entirely with MEEHANITE castings. Cushions of this type are used in presses as shown.

IN THE DESIGN of new products or redesign of old ones engineering thinking turns to Meehanite castings for *extra* characteristics. A typical example is found in the new and specially designed Hydro-pneumatic Press Cushion illustrated.

For this unit 5 specific characteristics had to be provided in combination. These were:

(1) High Strength
(2) Pressure Tightness
(3) Wear Resistance
(4) Hardenability
(5) Resistance to Erosion.

The cushion which is suspended in the bed of the press (see sketch) exerts an upward thrust on the blankholder in the draw die and gives the same effect as a mechanically operated blankholder in a double action press. It operates at a working pressure of 1000 psi and the 21″ diameter ram delivers thrust pressures up to 170 tons. The press can operate at a speed of 14 strokes per minute.

A Meehanite plate, hardened to about 500 Brinell, is provided to protect the top of the cylinder from the pounding of the pressure pins.

Cylinder, ram and control valve parts are Meehanite castings, the valve and removable valve seat also being heat-treated for hardness to increase erosion resistance to the oil which passes the valve and seat in large volume at high velocity.

Write for our Bulletin No. 10 "Meehanite—the Metal for Pressure Castings."

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E. W. Bliss Co.	Hastings, Mich. and Toledo, O.
Builders Iron Foundry Inc.	Providence, R. I.
H. W. Butterworth & Sons Co.	Bethayres, Pennsylvania
Continental Gin Co.	Birmingham, Alabama
The Cooper-Bessemer Corp.	Mt. Vernon, Ohio and Grove City, Pa.
Crawford & Doherty Foundry Co.	Portland, Oregon
Farrel-Birmingham Co., Inc.	Ansonia, Connecticut
Florence Pipe Foundry & Machine Co.	Florence, New Jersey
Fulton Foundry & Machine Co., Inc.	Cleveland, Ohio
General Foundry & Manufacturing Co.	Flint, Michigan
Greenlee Foundry Co.	Chicago, Illinois
The Hamilton Foundry & Machine Co.	Hamilton, Ohio
Johnstone Foundries, Inc.	Grove City, Pennsylvania
Kanawha Manufacturing Co.	Charleston, West Virginia
Koehring Co.	Milwaukee, Wisconsin
Lincoln Foundry Corp.	Los Angeles, California
The Henry Perkins Co.	Bridgewater, Massachusetts
Pohlman Foundry Co., Inc.	Buffalo, New York
Rosedale Foundry & Machine Co.	Pittsburgh, Pennsylvania
Ross-Meehan Foundries	Chattanooga, Tennessee
Shenango-Penn Mold Co.	Dover, Ohio
Standard Foundry Co.	Worcester, Massachusetts
The Stearns-Roger Manufacturing Co.	Denver, Colorado
Traylor Engineering & Mfg. Co.	Allentown, Pennsylvania
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Vulcan Foundry Co.	Oakland, California
Warren Foundry & Pipe Corporation	Phillipsburg, New Jersey
Washington Machinery & Supply Co.	Spokane, Washington
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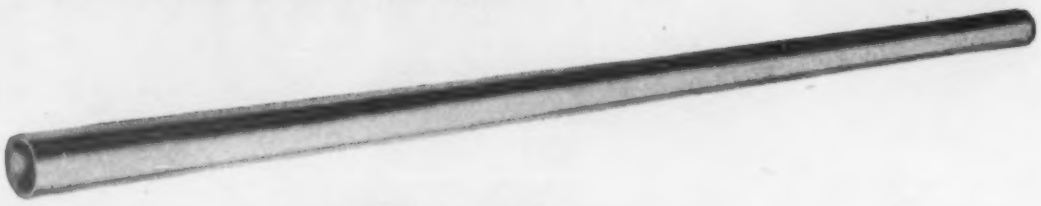
MEEHANITE®

PERSHING SQUARE BUILDING • NEW ROCHELLE, N. Y.

THE WIZARD *would be stumped!*

Years ago the "wise" men often conjured up some fantastic, not to say, amazing gadgets. These magicians from the past would be *stopped cold* however, if they could see the many remarkable applications of *today's* Superior Fine Small Tubing (.010" to .625" O.D. Max.). Of course, not all of the mechanical marvels of this modern world incorporate Superior tubing, but you can be sure that where it is used (seen or unseen), it is doing the job perfectly.



for instance . . .

SUPERIOR STAINLESS STEEL TUBING—used wherever a combination of properties: corrosion resistance, high strength, heat resistance, machineability, etc., are required. The tubing could be a part of a food processing machine, a carburetor, a condenser or an oil burner.

SUPERIOR NICKEL AND NICKEL ALLOY TUBING—finds acceptance in a wide range of uses from cathodes in electronic tubes, to machine parts for chemical and processing equipment—anywhere tubing must meet rigid requirements of strength, hardness, toughness, corrosion or heat resistance.

SUPERIOR CARBON STEEL TUBING—might be a machine part, a part of a toy, a valve part, a bushing or a component in a modern electrical appliance.

SUPERIOR BERYLLIUM COPPER TUBING—combining high fatigue and abrasive resistance, durability, low drift and good electrical conductivity, Beryllium Copper tubing finds wide application in calculating machines, electrical appliances, bourdon springs and sporting goods.

Write today for your copy of Bulletin #31.

THE BIGGER NAME IN SMALL TUBING *Superior*

(.010" to 5/8" O.D. MAX.)

SUPERIOR TUBE COMPANY
2006 Germantown Ave.
Norristown, Pennsylvania

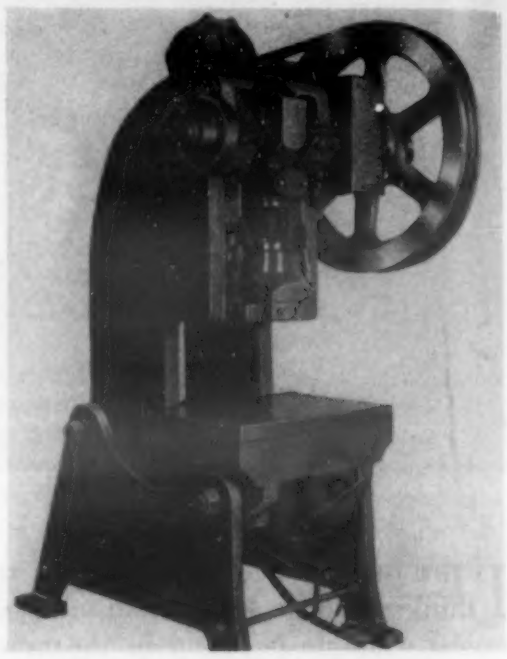
For Superior tubing on the West Coast, call PACIFIC TUBE COMPANY, 5710 Smithway St., Los Angeles 22, Cal. ANgeles 2-2151

Punch Press With Self Energized Brake

The *Superior Punch Press Co.*, 3601 Superior Ave., Cleveland, Ohio, has brought out a new steel welded punch press in 70- and 100-ton capacity. This press features a brake which is applied only at the moment of clutch disengagement. The brake is self energizing; therefore, the braking increases in pressure until the crankshaft reaches zero speed.

The brake action is synchronized with the clutch so that when the clutch engages, the brake disengages and remains free while the press is in motion. As a result of this, considerable saving of horsepower is claimed and also the life of the brake lining is said to be increased 500%. This is due to the elimination of brake drag.

The clutch is cam controlled. No pins are used, for the cam is mounted on the crankshaft which works the throwout yokes resulting in a positive clutch action. With this arrangement the wear on all the clutch parts has been practically eliminated. The 70-ton press main bearings are 4½ in., connection bearing 6 in., standard stroke 3½ in. (longer stroke can be furnished), bolster plate 22 by 32 in., weight 11,000 lb.



The press features a self energized brake.

New Silicone Rubber Product

A silicone rubber coated asbestos paper has been announced by the *Connecticut Hard Rubber Co.*, New Haven, Conn. The material has high heat resistance, withstanding temperatures in the range of 500 F and cold resistance down to −70 F. It has a dielectric strength of 400 v. per mil, which means that in the thickness of the present material of 0.024 in. there is a dielectric of some 9600 v.

The material is said to be more resilient than untreated asbestos paper, which makes it suitable as a gasketing or a washer where compression will aid in sealing or holding.

The material is also corona resistant, weather resistant, it will not carbon track, and has high surface resistivity. It is available in rolls 12 in. wide.

They're All Constructed With Adaptable

REFRACTORY CONCRETE

Refractory Concrete flues for open-hearth furnace. Walls, arches and manholes cast in place without joints.

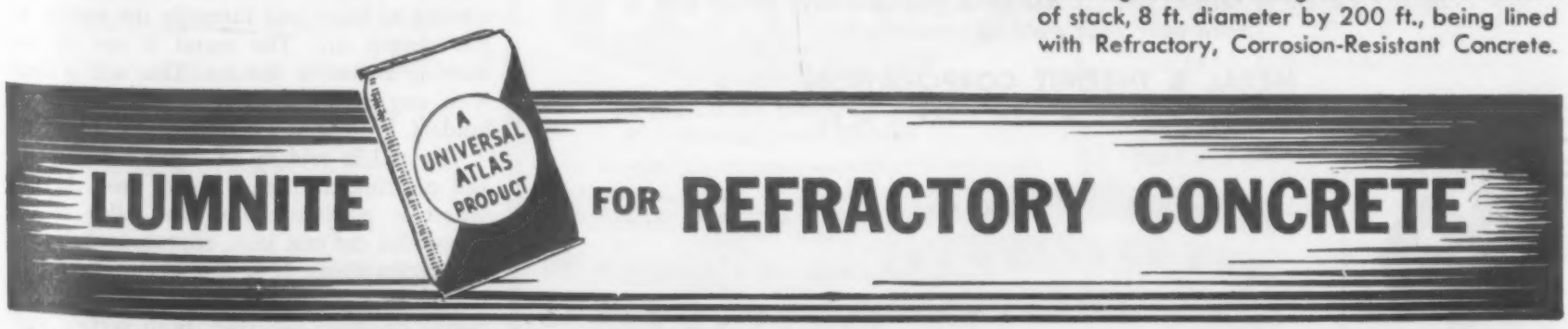
Cast-in-place roof arch of Refractory Concrete. A 14-ft. span in a periodic brick kiln.

. . . and described in these FREE booklets

You get construction savings, service savings and upkeep savings with Refractory Concrete. Made with LUMNITE cement and selected aggregate, Refractory Concrete is highly adaptable to a variety of installations. It can resist heat, act as insulation and resist corrosion. In addition, Refractory Concrete is easy to install, and full working strength is gained within 24 hours after placing.

Send for these free illustrated booklets. They point the way to savings in time and construction costs. They tell how to reduce maintenance work by using Refractory Concrete made with LUMNITE. Write today! LUMNITE DIVISION, Universal Atlas Cement Company (United States Steel Corporation Subsidiary), Chrysler Building, New York 17, New York.

Shooting LUMNITE lining in steel stack. Section of stack, 8 ft. diameter by 200 ft., being lined with Refractory, Corrosion-Resistant Concrete.



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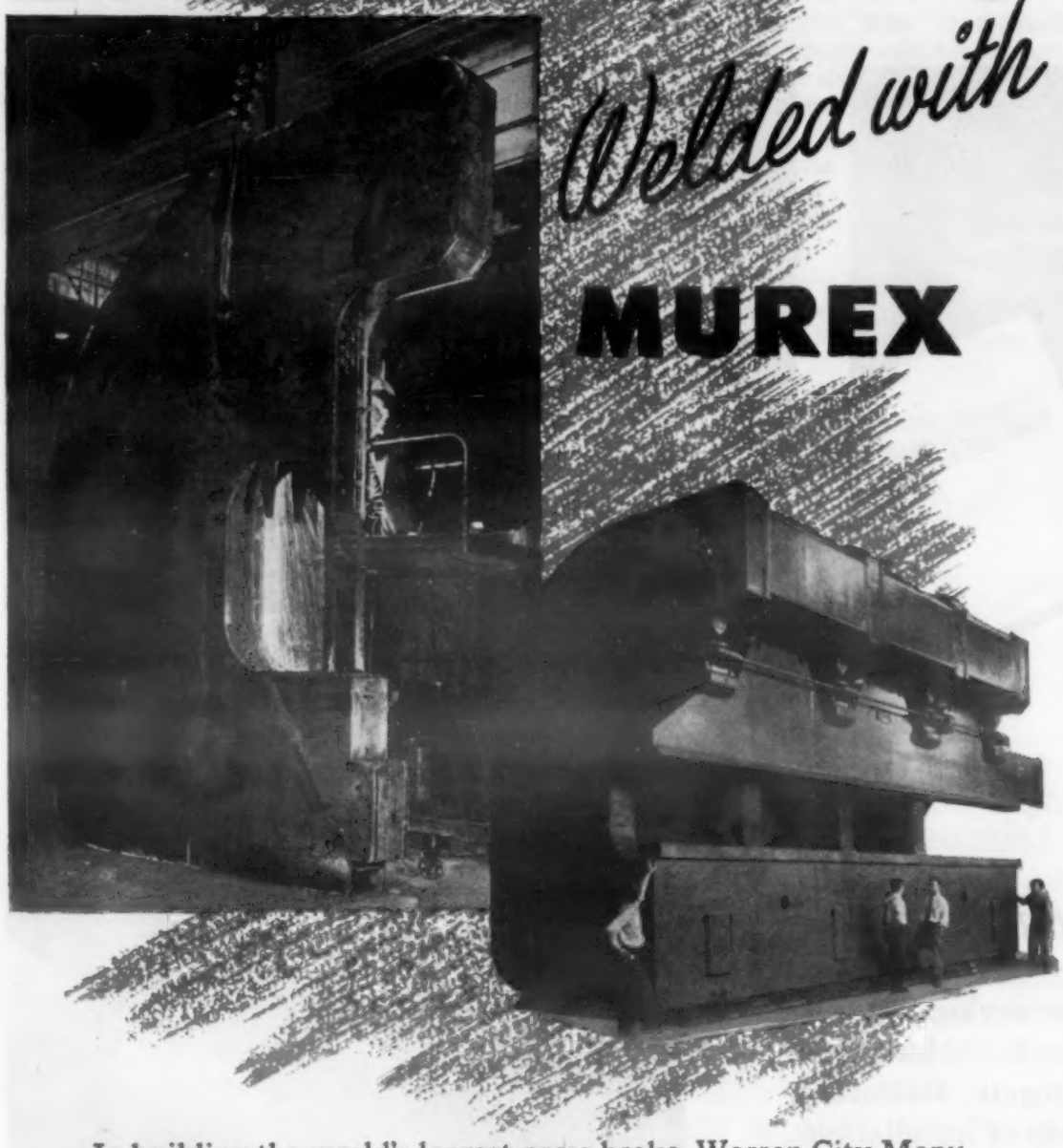
Welded with

MUREX



In building the world's largest press brake, Warren City Manufacturing Company made sure of top quality welding by using Murex Electrodes.

This huge unit, of fully stress-relieved welded steel construction weighs more than a half million pounds without dies. It is designed to exert a pressure of over 1,000 tons for bending steel plate 5/8" thick to a right angle and in a single stroke in lengths up to 36 feet.

Manual welding involved the equivalent of 40,000 feet of 1/4" fillet welding requiring more than ten thousand pounds of GENEX, FHP and HTS rod.

M & T can be of help to you . . . Ask for a representative to call and check over your welding operations.

METAL & THERMIT CORPORATION
120 BROADWAY • NEW YORK 5, N. Y.

MUREX WELDING ELECTRODES
M&T ELECTRODES and GAS RODS
M&T WELDING ACCESSORIES

Portable Hardness Tester Has 4-In. Capacity

A 4-in. capacity portable hardness tester weighing slightly over 3 lb. and reading directly in the Rockwell hardness scales is offered by *Ames Precision Machine Works*, Waltham 54, Mass. Rounds and flats, both hard and soft, from very thin up to 4 in. can be tested.

The frame is shaped like that of an ordinary 4-in. micrometer and is sprung slightly when pressures are applied to the penetrators by turning the handwheel. A diamond penetrator is used for testing hardened steel, and ball penetrators for testing soft materials, as specified in the Rockwell chart.

A lever extends across the front of the frame which actuates the dial indicator when pressures are applied and released. The indicator dial has graduation lines which show when pressures of 60, 100, and 150 kg. are applied by turning the handwheel.

Vertical Spindle Grinder for Castings

A new type 72-in. vertical spindle grinder originally designed for grinding cast iron gear housings has been designed by *Charles H. Besly & Co.*, Chicago 6.

The new grinder features a power-driven rotary fixture into which the operator places the casting. The rotating fixture and revolving work holders carry the castings through the grinding cycle at one revolution every 60 sec. Four pieces are ground simultaneously. Approximately 1/32 in. is removed. When smaller castings are ground, two or more can be placed in each work holder.

The machine is adaptable to other types of production grinding. The new grinder with its novel use of revolving work holders in a rotating fixture is said to step up output and quality as compared with the best manual grinding.

Electrode Used for Surface and Underwater Metal Cutting

A new metal cutting electrode has been announced by *Eutectic Welding Alloys Corp.*, 40 Worth St., New York 13. The electrode can be used with any conventional a. c. or d. c. welding generator to cut practically all common metals and alloys.

The cutting electrode, known as Cut-Trode, is covered with an exothermic flux coating to focus and intensify the energy of the electric arc. The metal is cut by the melting action of the arc. This rod is used with any of the regular welding electrode holders. No gas or oxygen is required.

The rod is said to be capable of cutting and piercing through 4 in. of steel. In addition to cutting carbon and alloy steels, it can also cut cast iron, copper, nickel, and aluminum alloys. It is said to cut effectively at high or low currents, depending upon the degree of speed required. Both surface and underwater cutting are possible.

AUTOMATIC
STATION-TYPE
CONVEYORS
FOR
Bullard-Dunn Descaling . . . Pickling . . . Bright
Dipping . . . Plating . . . Blackening . . . Heat
Treating . . . Hot Tinning . . . Rubber Mould
Cleaning . . . Phosphate Coating . . . Treatment
Aluminum, Zinc

. . . *Engineered to specific requirements*

To keep a sequence of treatments right on schedule with the least effort, let an amazingly low-priced Bullard-Dunn Station-Type Conveyor, engineered to your specifications, take over the job.

It's fully automatic—with a timer which the operator can set to accurately time any cycle of treatments involving 5 to 20 stations. Manual operation by push-button control for the lifting, indexing and lowering functions is also possible.

It's hydraulic—with the oil reservoir built into the column for compactness. Its Geneva type of index motion produces smooth movement of work from station to station.

It's a Bullard Machine—made to conform with our machine tool standards. Ruggedness equips it to handle heavy, unbalanced loads through high lifts. Simplicity of design and few parts combine to give smooth operation and uninterrupted service.

It's job-tested—has been used for ten years for such processes as Bullard-Dunn descaling, pickling brass and bronze, tinning refrigerator condensers, soldering auto radiators, treating aluminum and zinc, and plating all kinds of metals.

Rotating cylinders and driving mechanism attachments are available for handling small parts.

For complete details write for Bulletin MM-BD41. The Bullard Company, Bullard-Dunn Process Division, Bridgeport 2, Connecticut.

BULLARD

Bullard-Dunn Descales Without Dimensional Change

The Bullard-Dunn Process removes scale and oxide from ferrous metallic surfaces without attacking the work. Fast . . . thorough . . . economical . . . simple to operate. Investigate. Bulletin BD-42 tells story.

CREATES *NEW METHODS*
TO MAKE MACHINES DO MORE

"FALLS BRAND" ALLOYS

AMERICA'S LARGEST PRODUCERS OF ALLOYS

"FALLS" FLUX "B" for BRASS AND BRONZE

•

"FALLS" Flux "B" cuts melting costs by reducing rejections and scrap caused by dirty metal.

1. It increases metal yield about 3% by putting all the metal usually lost in the dross back into the molten metal.
2. It cleans, fluxes and removes gases, oxides and non-metallic impurities from all grades of brass and bronze.

A dry white powder, "FALLS" Flux "B" does not smoke, fume or smell, will not absorb moisture, and can be handled with the bare hands without burning the skin.

•

WRITE FOR COMPLETE DETAILS

NIAGARA FALLS

Smelting & Refining Division

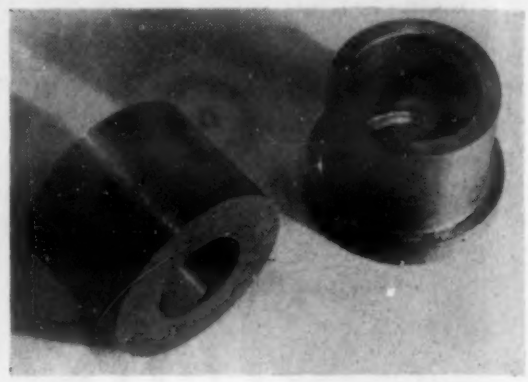
Continental-United Industries Co., Inc.

BUFFALO 17, NEW YORK

New Alloy Has Density Greater Than Lead

An alloy of tungsten, copper and nickel, known as Hevimet, has been developed by *General Electric Co.*, Pittsfield, Mass. The alloy possesses a density 50% greater than lead and is applicable to the design and construction of moving parts possessing maximum inertia and minimum size.

Originally developed in response to demands for a material of high density for use on a gamma ray screen, Hevimet is



Gyroscope rotors made with the new alloy, Hevimet, possess maximum inertia with minimum size.

adaptable to the construction of balance weights for the elimination of vibration in crankshafts, modern air screws, centrifugal clutches and other rotating parts. Combining great tensile strength with good machinability, the alloy is said to be highly resistant to atmospheric salt water corrosion and easily plated with cadmium, chromium and nickel. It can be silver soldered and brazed by standard methods.

A sintered material, Hevimet is made in a variety of nonporous sheets and blocks. Complex shapes may be built up from simple pressing by a special process of hydrogen welding. The average product has a density from 16.8 to 17 grams per cu. cm., a tensile strength of 85,000 to 118,000 psi., and a Rockwell hardness of 30 to 40 C scale.

Two New Small Size Arbor Presses

To meet the needs for fast-operating, semi-automatic equipment suitable for production operations, *Hannifin Corp.*, 1101 S. Kilbourn Ave., Chicago, is now building two new air operated arbor presses. Designated as models M-1 and M-2, both feature a new push button controlled electric valve which eliminates manual valve operation and speeds up the operating cycle.

Model M-1 is equipped with a 4½-in. dia. by 4-in. stroke air cylinder and develops up to 1270 lb. ram pressure with 80-lb. air line pressure. On Model M-2, the cylinder measures 6½ in. dia. by 6 in., and is capable of delivering ram pressures up to 2650 lb.

In both presses, the stroke can be varied to meet work requirements.

do you know?

MARK the Problem and MAIL the Adv.

The answers, step-by-step, will come first class post-haste to you

Metal Finishing Quiz

- HOW TO *nickel plate upon aluminum.*
- HOW TO *clean and remove rust from steel in one operation at room temperature.*
- HOW TO *color brass a beautiful Antique English color.*
- HOW TO *shed water from metals to prevent staining or spotting during drying*
- HOW TO *trap fumes from hot sulphuric acid pickles.*
- HOW TO *overcome cloudiness of bright nickel plate.*
- HOW TO *strip alkyd enamels from aluminum at room temperature without attacking aluminum.*
- HOW TO *prepare lead alloys for plating.*
- HOW TO *shorten alkali cleaning time for steel to 15 seconds.*
- HOW TO *remove solid dirt and oil from metals.*
- HOW TO *blacken copper, brass, zinc and steel.*
- HOW TO *make paint stick to brass.*
- HOW TO *get blister free copper and nickel plates on zinc slush castings and die castings.*
- HOW TO *barrel plate upon aluminum.*

NO OBLIGATION . . .
AN ENTHONE RESEARCH SERVICE

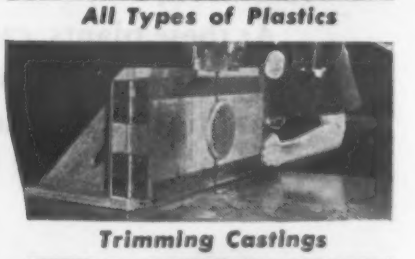
ENTHONE, INC. *Metal Finishing Chemicals*
442 ELM STREET, NEW HAVEN

Friction Sawing with Tannewitz HIGH SPEED BAND SAWS

1" Armor Plate

Hard Tempered Steel

All Types of Plastics

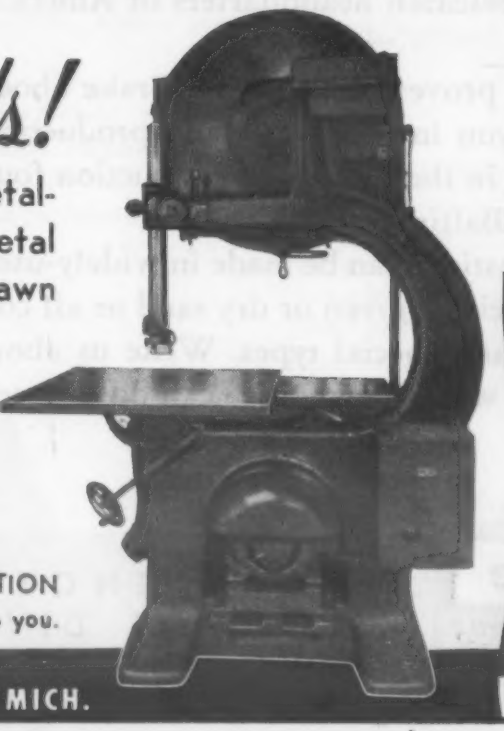


Trimming Castings

Metal Hard As a File

Obsoletes other Methods!

The most authoritative magazine in the metal-working field says: "Steel and other ferrous metal sections under 1 inch in thickness are friction sawn so rapidly as to render any other cutting procedure obsolete." The same is true of sawing non-ferrous materials formed or flat, castings, hardened steels, plastics, wood and a host of other materials.



Write for your copy of our free booklet "FRICTION SAWING"; it will prove a revelation to you.

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give you
THE BEST FOR YOUR PURPOSE

CASTINGS BY BRAKE SHOE

• Meehanite® • ABK Metal •
Gray Iron, plain or alloyed

• In this completely equipped experimental foundry you can get impartial experience-based recommendations as to which of these three types of metals will serve you best for your cast parts. It is one building of a group at Mahwah, N. J., the national research headquarters of American Brake Shoe Company.

Whichever metal proves best for you, Brake Shoe foundry techniques can benefit you in both pilot and production foundries at Mahwah, N. J., and in the company's production foundries at Melrose Park, Ill., and Baltimore, Md.

At these plants, castings can be made in widely-used types (light, medium or heavy weight, green or dry sand or all core assemblies) including intricate and special types. Write us about your needs; let us tell you what we at Brake Shoe can do to meet them.

6205

AMERICAN Brake Shoe COMPANY

BRAKE SHOE AND CASTINGS DIVISION
230 PARK AVENUE, NEW YORK 17, N. Y.

Improved Bright Cadmium Plating Process

A new and improved bright cadmium plating process is reported by the *Hanson-Van Winkle-Munning Co.*, Matawan, N. J.

The process under optimum conditions is said to give deposits that are mirror-bright as they come from the plating solution. A short bright dip may be used in order to compensate for variations of current distribution because of limitations in racking or because of the intricate shape of the article being plated.

The process is also reported to have a higher tolerance for impurities. The range of the bath is from 20 to 40 amp. per sq. ft. with an optimum current density of 30 to 35 amp. per sq. ft. in still plating. With agitation, current densities up to 70 amp. per sq. ft. have been employed.

With regard to covering power, work has been done on rough base metal which indicates that a lower grade steel can be used, and still give a finished product that will pass inspection.

● Conduit-end bushings of diced phenolic molding material that has the desired combination of electrical insulation, smooth edges and high physical strength has been announced by the *Union Insulating Co., Inc.*, Parkersburg, W. Va. This plastic, called BM-49, is produced by *Rogers Corp.*, Manchester, Conn. Its preformability, low bulk factor, and ease of molding adapt it to the high production rate required for standard fittings of this kind.

Selector Increases Usefulness of Dew Point Recorders

A new selector for atmosphere gases for increasing the effectiveness of the dew point recorder has been announced by *Surface Combustion Corp.*, Toledo, Ohio. The unit makes it possible to analyze consecutively atmospheres from as many as six different sources—generators, furnaces, etc., in timed sequence.

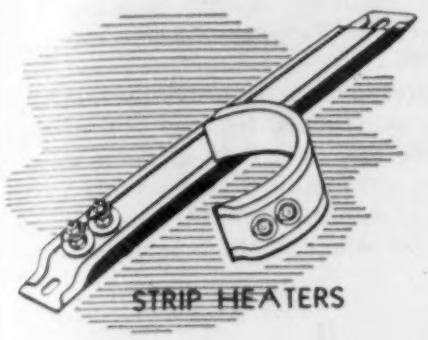
The atmosphere selector consists primarily of a six-way valve for six incoming atmosphere sources, a motor, and an electric time clock. The elements are so arranged that at a pre-set time the source of atmosphere supply to the dew point recorder is automatically switched from one line to the next. In the meantime, the five remaining lines which are not feeding the recorder are continuously purged so that when the next source is to be analyzed no time is lost in purging.

Since all six lines may not be needed when the manifold is first installed, the machine provides a means of skipping one or more lines and returning the inlet valve to the initial line automatically. Thus, additional capacity is available for later use without impairing the speed and initial versatility of the unit.

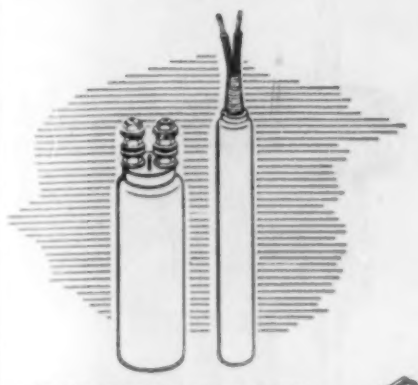
No provision is made to cause the valve to automatically skip one individual intermediate line, as all lines in use can readily be connected in consecutive order. The control switch for skipping the sampling lines is located inside the unit.

CHROMALOX ELECTRIC HEATERS

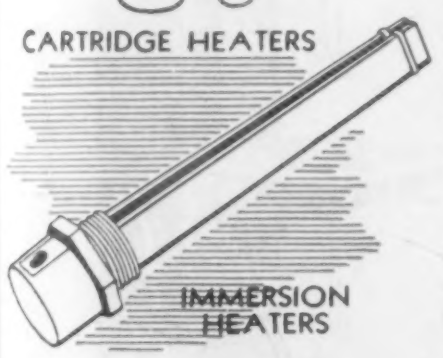
Standard types in popular sizes are available for immediate delivery.



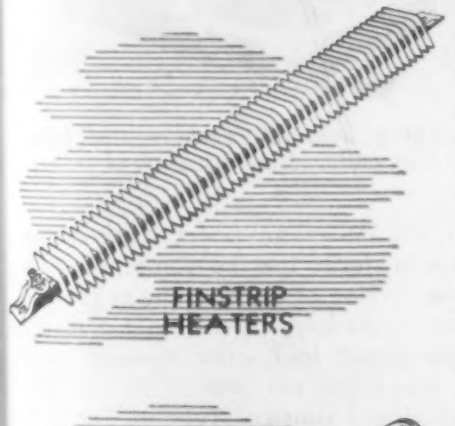
STRIP HEATERS



CARTRIDGE HEATERS



IMMERSION HEATERS



FINSTRIP HEATERS

TUBULAR HEATERS

HEAT—Made to Order

WHEN AND WHERE YOU WANT IT!

Illustrated is a tank heated with Chromalox ELECTRIC Strip Heaters.

with

CHROMALOX *Electric* Heaters

- FAST—CHROMALOX *Electric* Heaters give you instant heat in the exact spots where it is needed without unnecessary heat-losses. They quickly build up to desired working temperatures.

- UNIFORM—Close operating temperatures, accurately maintained through thermostatic or manual controls, assure you uniform products.

- DEPENDABLE—Performance proved CHROMALOX Units provide efficient day-in-and-day-out service at low initial-cost, low operating-costs and minimum maintenance-attention.

If you are a user of industrial heat, you will find that you too can save time, money and labor by using CHROMALOX *Electric* Heaters in your plant or product. CHROMALOX Heaters provide economical, efficient and reliable service in thousands of applications ranging from heating liquids, gases and viscous fluids to heating molds, platens, tanks and moving parts.

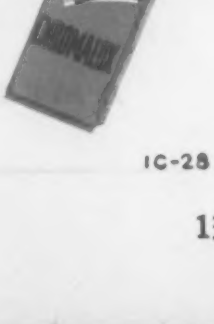
ENGINEERING SERVICE—A nation-wide organization is available for "on the job" assistance at no cost to you. The Chromalox Engineer nearest you will be glad to show you how efficient and economical electric heat can be used in your plant or product.

CHROMALOX

Electric HEAT FOR MODERN INDUSTRY

WANT HELPFUL IDEAS?

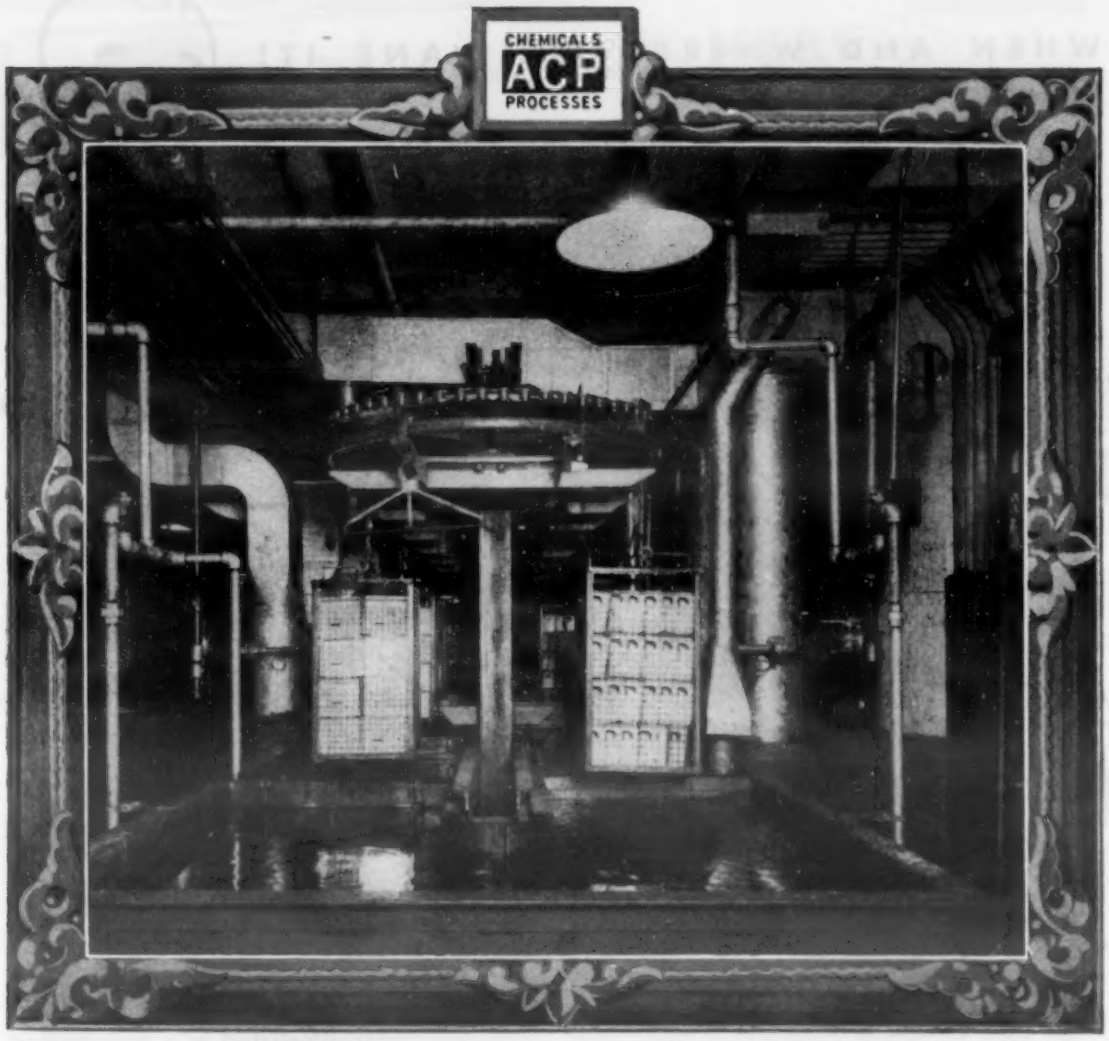
The booklet "100 Ways to Apply Electric Heat" and Chromalox Catalog 42 contain a wealth of informative data on the use of electric heat in industry. Send for your copies today.



EDWIN L. WIEGAND COMPANY
7523 Thomas Boulevard, Pittsburgh 8, Pa.

IC-28

Picture of Progress



ALODIZING Aluminum Regulator Covers in Mechanized Equipment.

Photograph courtesy of the Minneapolis-Honeywell Regulator Company

Alodizing — A NEW ORDER OF DURABILITY FOR ALUMINUM

CHEMICALS ACP PROCESSES

RUST PROOFING AND PAINT BONDING

Granodine *
Duridine *
Alodine *
Lithoform *
Thermoil-Granodine *

RUST REMOVING AND PREVENTING

Deoxidine *
Peroline *

PICKLING ACID INHIBITORS

Rodine *

*®

ALODIZING, the modern ACP chemical process utilizing "ALODINE"*, provides the utmost in protection for both painted and unpainted aluminum.

ALODIZING greatly increases aluminum's natural resistance to corrosion and transforms its surface into a durable bond for firm finish adhesion.

This new process requires no electricity—elaborate equipment—or high temperature. Operated effectively at 120° F., ALODIZING requires but 2 minutes for application by immersion, or 30 seconds when applied under pressure in a power spray washer.

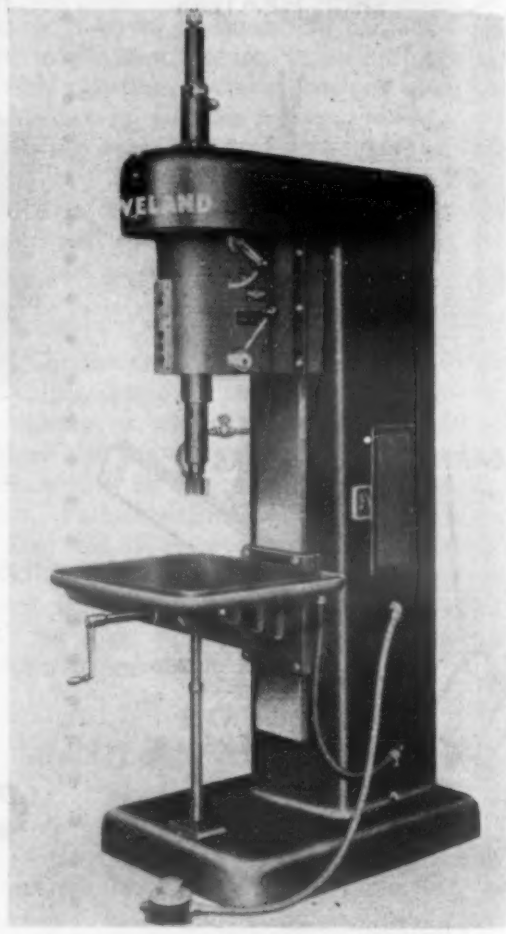
Simple, rapid and economical, "ALODINE" makes high quality aluminum protection available to all industry and all types of production.

AMERICAN CHEMICAL PAINT CO.
AMBLER ACP PENNA.

Tapping Machine Designed for Multiple Heads

Higher speeds and economy in precision production tapping are claimed for the new tapping machines recently announced by the *Cleveland Tapping Machine Co.*, Harville, Ohio.

Employing the interchangeable lead screw feed, it is designed for use with multiple heads for tapping groups of holes, even of different sizes, with a single stroke of the spindle. Adjustable heads can be used where the pattern of the hole varies in production and indexing tables; cross slides and hopper feeds can be combined with automatic cycling of the machine to provide automatic operation.



The tapping machine employs an interchangeable lead screw feed.

The tool-steel lead screw operates in a bronze lead-screw nut with 2 in. of full-diameter thread contact. Tapping depth is controlled within 0.005 in. by means of a dial on the side of the head, making blind-hole tapping safe and simple.

Spindle speeds can be changed by a belt change on multiple pulleys, and the operation of the machine may be fully automatic or manually controlled by means of push-button or foot switch.

● A hydraulically-operated stock feed for use on almost any punch press has been announced by *Haller Machine & Mfg. Co., Inc.*, 7904 Tireman Ave., Detroit 4. This unit handles all stock up to 4 in. wide and 3/32 in. thick, and feeds any desired length from 0 in. to 5 in., within 0.003 in. to 0.005 in. every time. Known as the Haller Model D-600 Hydraulic Stock Feed, this unit is compact and entirely self-contained.

For a **COMPLETE LINE OF BABBITTS** to use at any load or any speed . . . for the answers to all bearing metal problems . . . for fast deliveries and friendly service . . . call the nearest Federated office.

All of Federated's 25 sales offices and 11 plants are linked . . . joined . . . in a common purpose—to bring you the advantages of the uniformly good facilities which this huge organization maintains.

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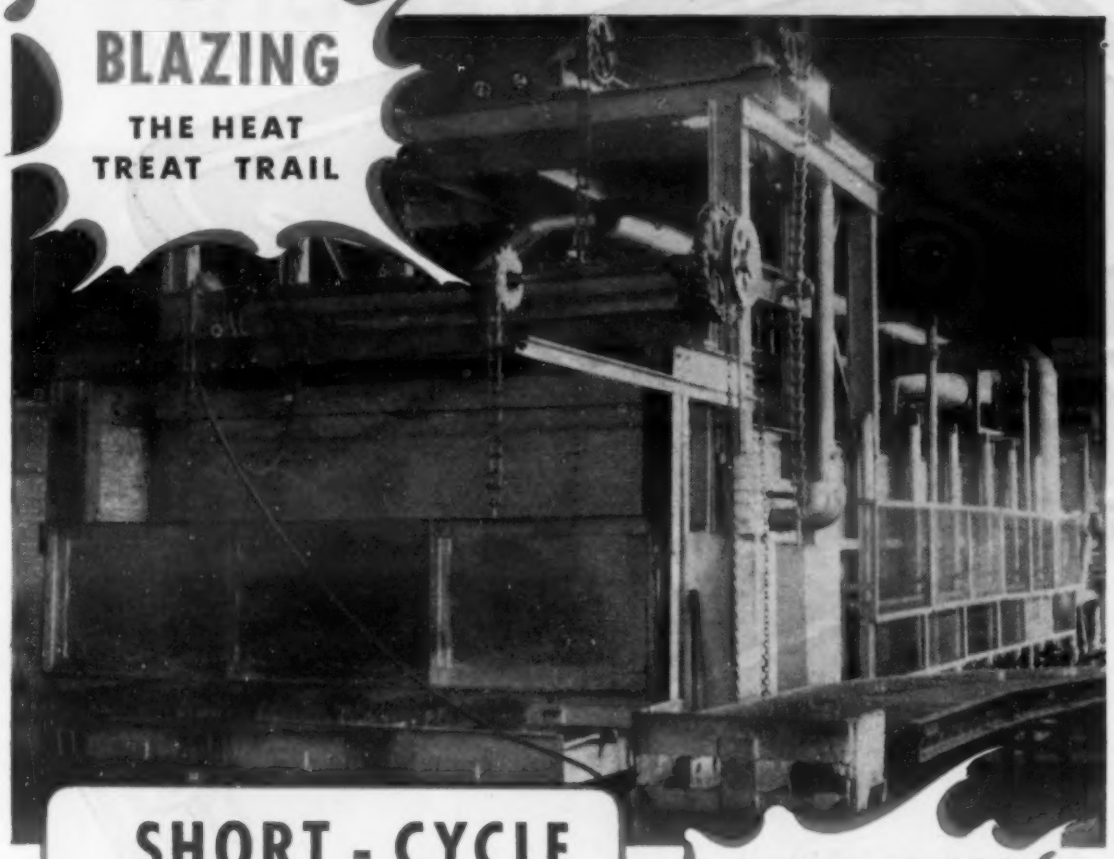

Another example of Holcroft "trail blazing"—the first radiant tube continuous furnace for short-cycle malleable annealing, installed more than 10 years ago and still producing economically.

SHORT-CYCLE MALLEABLE ANNEALING FURNACE

DEVELOPED BY *Holcroft* IN 1936

Short-cycle malleable annealing is a fast, economical process which offers the following advantages to large-volume manufacture:

- The process requires as little as *14 hours*, as compared to *several days* for other methods. This means reduced inventories and faster shipments.
- It produces *clean, scale-free work* which can go directly to shop or assembly without further processing.
- It permits the use of *light-walled containers* — reduces dead weight by as much as 400%, and cuts fuel bills correspondingly.
- It enables large and small castings to be handled simultaneously.
- Compared to other methods, it gives several times the production per unit of floor area.

Although continuous furnaces are most frequently used, this process is also successfully applied to batch-type furnaces. As with all Holcroft furnaces, each installation is *designed individually* for the specific application, thus meeting every requirement of production and quality with maximum over-all economy.

In ordering production heat treat furnaces for ANY need, it will pay you to take advantage of Holcroft engineering leadership. And remember—Holcroft offers you *complete metallurgical and engineering service*, from individual furnace design through the trial run in your plant.

PRODUCTION HEAT TREAT FURNACES FOR EVERY PURPOSE

BUILT BY HOLCROFT & COMPANY DETROIT-MICH.

SINCE 1916

HOLCROFT & COMPANY

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DETROIT 10 • MICHIGAN

Chicago 3: C. H. Martin
1017 Peoples Gas Bldg.

Houston 1: R. E. McArdle
5724 Navigation Blvd.

Canada: Walker Metal Products, Ltd., Walkerville, Ontario

Punch Press for Tool Room and Production Work

A new 38-ton capacity, open back, inclinable punch press has been added to the line manufactured by the *Walsh Press & Die Co.*, Div. of *American Gage & Machine Co.*, 4709 W. Kinzie St., Chicago 44. Equipped with a variable speed drive, this model serves well as a tool-room and test-run press or as a production press.

In the tool room the press can be used for shearing-in of dies and punches and for die try outs. Used for die try outs in place of a screw press, it will give an exact indication of results on the production run.

The large shut height and bolster plate area make this press adaptable to certain notching, forming and die-casting trimming operations where plenty of room is required. It has a distance between gibs of 17 in., a bed area 18 in. by 26 in., and a throat depth of 12 in.

It can be furnished with up to a 6-in. stroke in either a flywheel type or a back geared type and with either a variable speed drive or conventional motor drive.

Three New Comparators

A new optical projection comparator, equipped with a precision-built lens system for projecting magnified contour images, has been announced by *American Optical Co.*, Southbridge, Mass. The new comparator is portable, and can easily be moved about the plant on retractable roller-bearing casters.

The basic unit is usable either on a bench or its own pedestal, and is adaptable for inspection of production pieces or as a microscopically precise measuring device. The possible applications range from pins to propellers and from taps to turbines.

The viewing screen has a 16-in. image area. Its texture is designed for maximum accuracy and even illumination. The projected image corresponds to the work profile as viewed from the operating position. Interchangeable magnifications of 10X, 20X, 31.25X and 62.5X are made possible by bayonet mounts.

Among the features of the comparator are parfocal and paramagnified lens systems adjusted for correct magnification and focus. Illumination is controlled by iris diaphragm correctly located in the lens system. The high-speed condensing system is factory adjusted and the bulb is pre-focused and pre-centered.

A new projector and optical comparator is also being placed on the market by the *George Scherr Co.* of 200 Lafayette St., New York 12. The design of the instrument is such that the comparator is suitable for continuous quantity inspection, as well as for the performance of delicate assembly operations on minute parts as occur in the watch, instrument, and electronic tube industry. To accomplish this, the work stage and the observation screen are close to each other, within the operator's reach and line of vision, respectively.

The instrument, when used for shadow images, has 6 different magnifications: 10, 20, 31¼, 50, 62½, and 100X. A special surface illuminator is available as extra equipment for reflected images in 10 and

ACME RESEARCH and PRODUCTION SKILL BRING YOU

Two Remarkable New Aluminum Casting Alloys

DESTINED TO PLAY STAR ROLES IN PRODUCT DESIGN

	MINIMUM	TYPICAL
Tensile strength, p.s.i.	50,000	55,000-60,000
Yield strength, p.s.i.	28,000	32,000-35,000
Elongation, 2"	16%	20% - 30%

ACME *Almag 55*

For the first time in aluminum history, Acme makes available aluminum castings with tensile strength in the 50,000-60,000 p.s.i. range.

This remarkable new alloy is Acme *ALMAG 55*, named for its aluminum and magnesium content. In addition to its great strength, it has unusually high elongation, impact resistance, and corrosion resistance. It machines well and has a beautiful, silver-like appearance that can be given a lasting polish or anodized, dyed or painted.

Due to its high guaranteed properties, Acme *ALMAG 55* can be considered for a wide range of applications including many in which cast and malleable iron and other heavy metals are now specified. Furthermore, Acme controlled casting and heat-treat techniques, lighter weight, and reduction in machining time combine to produce a favorable cost analysis.

	MINIMUM	TYPICAL
Tensile strength, p.s.i.	33,000	38,000-41,000
Yield strength, p.s.i.	15,000	18,000-21,000
Elongation, 2"	7%	10% - 15%

ACME *Almag 35*

Now you can obtain high strength aluminum castings *as cast*. Acme *ALMAG 35* offers maximum physical properties greater than aluminum alloys containing copper, zinc, or silicon even after these other alloys have been heat treated. This new Acme alloy is characterized by high corrosion resistance, 33,000 to 41,000 p.s.i. tensile strength (as cast), excellent ductility, and good machinability.

Generally speaking, Acme *ALMAG 35* offers the same advantages as the best previously available aluminum casting alloys . . . with the elimination of heat treatment. This is of unusual importance where heat-treat facilities are not available or where cost is an important factor. Furthermore, Acme *ALMAG 35* can be cast by sand, die, plaster, or permanent mold processes.

Available in either castings or ingots.

***ACME SERVICES:** aluminum, brass, bronze castings . . . aluminum casting alloys . . . patterns . . . tools . . . engineering . . . rare chemicals and rare metals . . . special specification alloys in wire or ingots*

TRIPLE A

Acme ALUMINUM ALLOYS, INC.

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A request on your company letterhead will bring you either or both of these technical bulletins. Send for your copies.

Cutler-Hammer, Inc. of Milwaukee, Wis., selected extruded Ampco Metal, Grade 22, for bumper-buttons in electrical switch boxes — because of its unique wear-resistant qualities.
Everything under control—
including costs!

—when you use wear-resistant extruded Ampco Metal

20 million impacts — without showing appreciable wear! That's the duty requirement set up by Cutler-Hammer, Inc. for the bumpers in electrical switch boxes. They needed a metal to do that job — at the rate of 30 impacts a minute (maximum). Extruded Ampco Metal (Grade 22) was selected. It did the job and passed inspection without a sign of peening or mushrooming. Its exceptional durability made important savings in maintenance and replacement costs.

Yes, the famed performance advantages of Ampco Metal more than met the operating requirements. And the production advantages of using extruded stock were three-fold:

1. Stock sizes closely parallel requirements — reducing waste.
2. Close size cuts machining time and tool costs.
3. Smooth surface and compact structure cuts rejections caused by hidden flaws.

Two grades of Ampco Metal and two grades of Ampcoloy (industrial bronzes) are regularly produced in extruded form by Ampco. Rods in a complete range of sizes are available for immediate shipment. Scores of companies now use extruded Ampco rod for product improvement and production economy. Give your plant this double advantage. For further data, write for Bulletin 64A today!

AMPCO
TRADE MARK REG. U. S. PAT. OFF.

Specialists in engineering, production, finishing of copper-base alloy parts.

Ampco Metal, Inc.
Dept. MA-1, Milwaukee 4, Wis.
Field Offices in Principal Cities
A -36

20X magnification. The screen is circular and 14½ in. in dia.

Provisions for five interchangeable tables and the use of standard indicators are features of the new model comparator developed by *Standard Gage Co.*, Poughkeepsie, N. Y. This comparator is therefore suited to a wide range of production and inspection measuring jobs. When equipped with the Micronar Indicator, it affords a means of checking plug gages.

Any AGD dial indicator of the No. 2 or No. 3 size having standard lug type back can be used. Thus, an indicator having graduations appropriate to the accuracy desired may be mounted on the comparator.

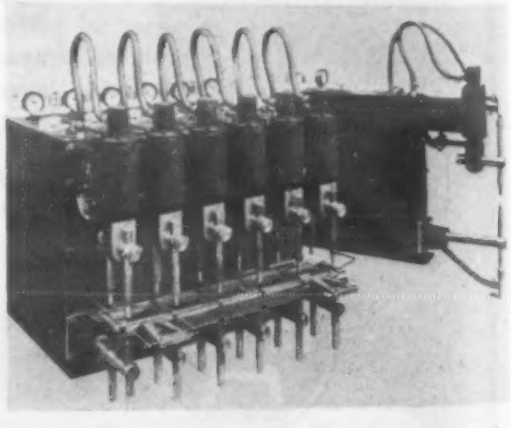
Raising, lowering, and approximate positioning of the indicator support arm are facilitated by a rack on the rear of the column. Fine adjustment for setting the comparator to a standard is effected by a wing handle. Pressure of the contact point on the work piece can be regulated by means of a knurled bushing. A reed mechanism within the head prevents side thrust from reaching the indicator and thus adversely affecting accuracy.

Tables are available as follows: 1½ in. by 4 in. serrated, 6 in. by 4 in. serrated, 1½ in. by 4 in. plain, and one with 1½-in. dia. rolls for checking local conditions.

Spot Welder Can Be Ganged for Multiple Welds

A spot welder suitable as a general purpose bench mounted welder, or ganged for multiple production, has been developed by *Metron Instrument Co.*, Denver 9, Col. It is only 4 in. wide; each unit incorporates controlled air-operated electrode pressure, adjustable current setting, electronic timing, water cooling of the transformer and electrodes, and automatic pressure initiation of current.

Electrode pressure is adjustable from 0 to approximately twice the air line pressure. Welding current is automatically applied after the electrode pressure has reached a predetermined pressure setting, which is adjustable from 0 to approximately 90 psi. in cylinder pressure.

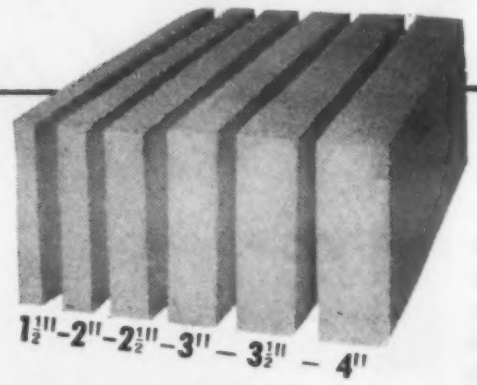


These spot welders can be operated upright, on their sides, or with the base upright.

When ganged for multiple welds, a single bank of these welders can be mounted for welding on 4-in. centers and two banks arranged face to face for welding on 2-in. centers. Multiple electrodes can be used in certain instances.

Why the lowest cost open hearth producers use SUPEREX for regenerator insulation

The large size of the Superex blocks saves construction costs



Superex blocks are furnished in various standard sizes and thicknesses

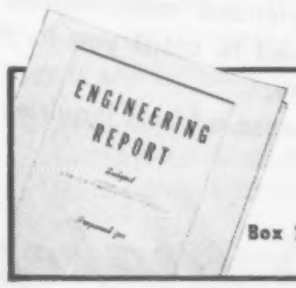
• "Insulate with Superex and you make substantial fuel savings and obtain higher operating temperatures," that's what cost-conscious operators find.

Superex provides these savings year after year. Made of calcined diatomaceous silica and asbestos, it presents a formidable heat barrier. It maintains its high insulating efficiency indefinitely on temperatures to 1900° F. . . . does not disintegrate . . . retains its high physical strength . . . resists the stresses of open hearth and other mill operations.

Higher operating temperatures with Superex result from its ability to reduce air infiltration. This advantage is traced to its unique structure and low permeability.

Superex is light in weight, easily cut and applied . . . comes in convenient standard sizes or may be ordered in irregular shapes.

To help you gain the greatest savings from Superex, Johns-Manville has prepared an engineering report, "Open Hearth Regenerators—a comparison of various insulation specifications." This report indicates the economic thickness of Superex to use as related to the costs of various types of fuels. To obtain this booklet, write Johns-Manville, Box 290, New York 16, N. Y.



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Box 290, New York 16, N. Y.

JOHNS-MANVILLE *First in* INSULATIONS

22,772 new products?

If each product engineer, designer and purchasing agent reading this advertisement could suggest one requirement, 22,772 new possibilities would result and we want new products for our parts fabrication department. Our specialties are . . . attention to detail in manufacture . . . ability to maintain close tolerance . . . and fine finishes.

Working on solid or laminated precious metals and base metals in sheet, wire and tubing which we fabricate in our mill operations, we have expanded our facilities for punch press and deep drawing work, milling, turning, grinding and drill press operations. In addition, we have facilities for assembly operations, silver soldering, silver furnace brazing and fine polishing.

We would welcome the opportunity to work with you on any production requirements you may have. Our staff of thoroughly experienced metallurgists, chemists and consultants will be pleased to assist you to the full extent of their facilities and ability.

Please address inquiries to Department M.

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D. E. MAKEPEACE COMPANY

Main Office and Plant, Attleboro, Massachusetts

NEW YORK OFFICE, 30 CHURCH ST. • CHICAGO OFFICE, 55 EAST WASHINGTON ST.

New Device Checks Dryness of Sand Foundry Molds

A new instrument that measures the evaporation of moisture from foundry molds has been developed by the *American Instrument Co.*, Silver Spring, Md.

By placing the instrument in contact with the surface of the mold, the evaporation of moisture can be accurately measured. Tests show that the best time to pour, in the case of sand-cement molds, is when the evaporation from the surface of the mold drops to approximately zero. Due to the porosity of a sand mold, the moisture evaporated from its surface is a function of the moisture present in the entire mold thickness and not just the surface layer.

The unit consists of an electric hygrometer sensing element. The operating principle of the electric hygrometer sensing element is based on the ability of a hygroscopic film to change its electrical resistance instantly with microchanges in moisture content.

Profiling Machine for End Machining Operations

General duty, automatic profiling machines for high production end-machining operations have been developed by the *Pines Engineering Co.*, Aurora, Ill. These machines are used for turning, boring, chamfering, burring, threading, tapping, etc., on the ends of pipe, tubing, bars, fittings, and other work of this type.

On one production job, the profiling machine chamfers both ends of ½-in. conduit, 10 in. long, at the rate of 800 to 1000 pieces per hr.; and the same machine is used to simultaneously chamfer both ends of screw machine rod stock at the rate of 700 to 900 pieces per hr.

The profilers are built for either manual or fully automatic operation. Automatic types are equipped with hydraulic controls, which repeat the machining sequence continuously. With the work hydraulically chucked, one or both ends are machined by the action of rotating head, which hold the cutters.

Either one or two heads are employed on the profilers. Two heads, however, permit the simultaneous machining of both ends of the work, resulting in higher output. The machining cycle is reduced, with extra handling of the work eliminated. In addition, the use of two heads on one machine often performs the same function required of two single spindle machines.

The fully automatic profilers may be set up to handle various lengths and diameters of work. Some applications are used to machine work less than an inch in length; others handle lengths up to 60 ft.

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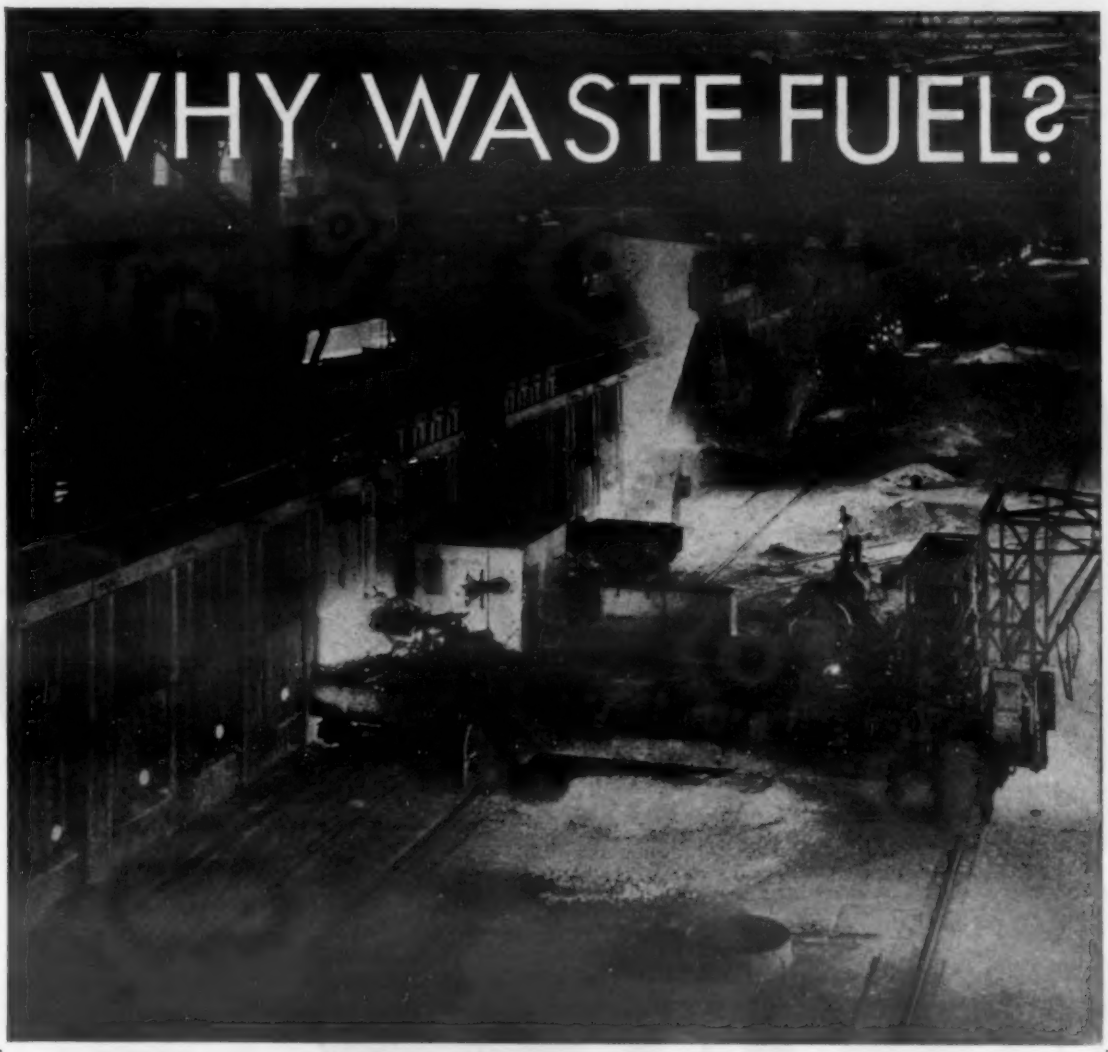

Therm·O·flake *prevents waste*
BY REDUCING HEAT LOSSES...

MORE THAN 25% of Open Hearth fuel can be wasted through heat lost through brickwork and heat absorbed by cold infiltered air.

Therm·O·flake INSULATIONS are designed to reduce heat losses and seal furnace walls against cold air infiltration. These are used regularly on hundreds of open hearth furnaces and save steel producers thousands of fuel dollars daily.

Therm·O·flake ENGINEERS will prepare an accurate fuel economy survey of existing furnaces in your plant and submit complete thermal data and recommendations for safe maximum insulation of any open hearth furnace, on request.

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Exclusive Manufacturers of
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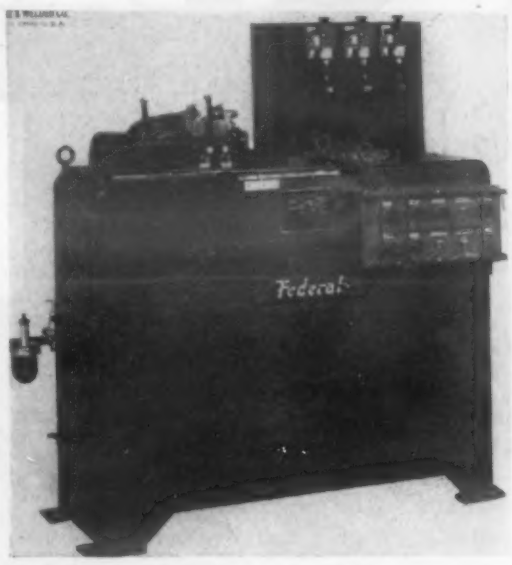
open hearth Insulation

● A process and method for making a heavy-wall, cast-iron, thermocouple protecting tube has been developed by the *Claud S. Gordon Co.*, Chicago. It is reported that this tube has a much longer life and is more practical and economical than the ordinary cast-iron tube used for molten aluminum, zinc and die casting metals. This new tube is furnished with a 3/8-in. wall thickness and a 15/16-in. inside dia.

Flash Welder Designed for Flat Steel Stock

A new flash welder, designated Type F-1, is designed for welding flat mild steel stock with a maximum width of 3 in. or for welding round and flat mild steel with a maximum cross section of 0.17 sq. in. The unit was developed by the *Federal Machine & Welder Co.*, Plant 2, Warren, Ohio.

The mechanical cam-type upset mechanism is located below the weld line in order to prevent obstruction above the weld line. Upset pressure of 2250 lb. is applied to the work when a platen opening of ¼ to 2 in. is used. Platen size is 12 by 12 in.

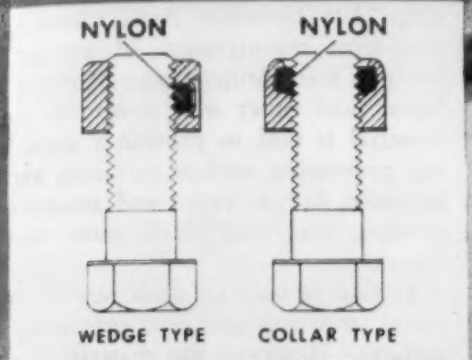


This flash welder has air-operated vertical clamp and adjustable upper and lower dies.

The machine is equipped with air-operated vertical clamps and adjustable upper and lower dies for correct positioning of the work. The control panel gives automatic or semi-automatic operation, and includes extra push buttons for individual clamping or unclamping. Three pressure switches accessible for adjustment operate individually on each cylinder as sequence and safety switches. The limit switch operating cams are mounted on the back of the machine to facilitate adjustment.

● For the benefit of shops who frequently find it necessary to drill holes in dies, fixtures, etc., after the metal has been hardened, *Super Tool Co.*, 21650 Hoover Rd., Detroit, announces a new line of standard carbide tipped drills designed specifically for this purpose. The new drill will be stocked for shipment in 10 sizes ranging from 3/16 in. to ¾ in.

Another new product from a Du Pont Plastic



200 LOCKUPS CAN'T LICK 'EM

New safer lock-nuts made possible by Du Pont nylon

WHAT'S NEW

Here's sales-building eye-appeal for frozen foods. This crystal-clear cover of Du Pont "Lucite" protects and insulates while it displays foods stored within the cabinet. It's strong enough to support carelessly placed shopping bags . . . light and easy to open . . . dimensionally stable. And this design resists fogging. "Lucite" is economically and easily fabricated. (Frozen food cabinet manufactured by Fraser and Johnston Manufacturing Company, San Francisco, California.)

Here's something never achieved before . . . self-locking nuts that can be taken off when desired and used as many as 199 additional times or more without losing their firm grip!

They're made with a tough, resilient insert of molded Du Pont nylon. Severe vibrational stresses can't budge them... only a wrench will remove them. For a given size, the 200th removal requires a torque that is only a few inch-pounds under that of the first removal. There's no deterioration in storage . . . little or no loss of structural strength caused by loosened lock-nuts. Nylon resists oils, solvents, gasoline, and moisture—shows little or no effect with age. These lock-nuts are easily and economically adapted to mass production . . . assure dependable, long-lasting service and safety in the fastening of vital parts.

Study the properties of nylon . . . and other Du Pont plastics. Like this manufacturer, you may find a way to develop a new product . . . or a means of improving an old one. Write now for literature. It will pay you to have it in your files. E. I. du Pont de Nemours & Co. (Inc.), Plastics Department, Room 411, Arlington, New Jersey.

Lock-nuts of various types with nylon inserts made by the Elastic Stop Nut Corp. of America, Union, N. J. and the Nylok Corp., 475 5th Ave., New York, N. Y

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...THROUGH CHEMISTRY

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A Processing Cartridge
. . . typical large centrifugal casting
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. . . typical small static castings

The cartridge weighs hundreds of pounds. The welding flanges weigh only a few pounds each.

Hardly a day goes by but such "contrasts in castings" show up in our foundry. With a battery of modern electric furnaces and the best obtainable foundry equipment, we are in position to turn out static castings up to 6 tons and centrifugal castings 24 inches O.D. and up to 15 feet long, depending upon the diameter.

If you want high alloy castings backed by experience, and produced under the best of conditions, come to Duraloy.

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1-DU-1

New Outdoor Coating for Metal Structures

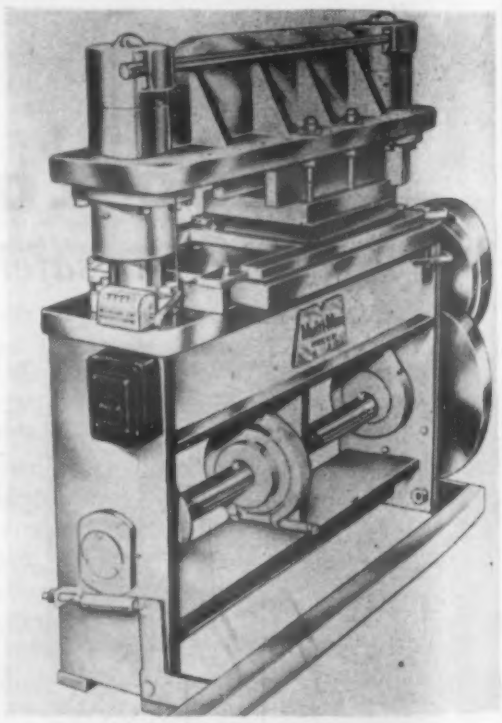
A new coating material for outdoor metal surfaces has been announced by the *Arco Co.*, 7301 Bessemer Ave., Cleveland. For long-term maintenance of storage tanks, bridges, transformers, water towers, harbor buoys, and other steel structures, this new material is said to provide a durable coating preventing surface corrosion and disintegration due to vapor and moisture transmission, acid and alkali gases, and other fumes.

It may be used on both new or uncoated metal structures and over previously coated surfaces. However, the material is not recommended for use over bituminous-type coatings.

New Production Line Press Is Versatile

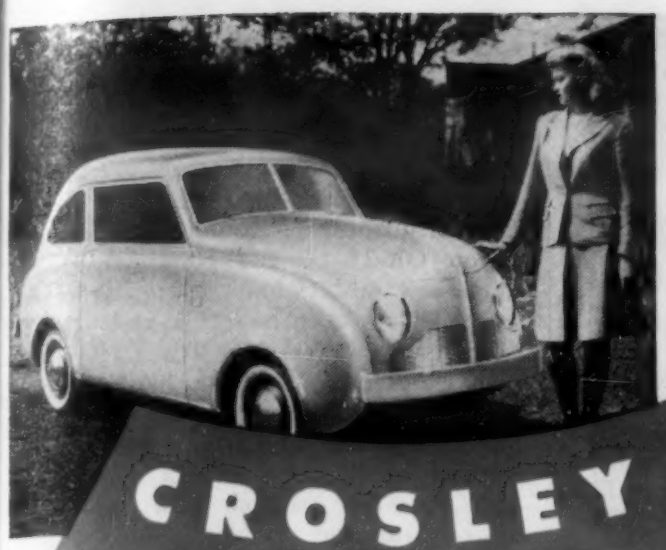
A new, 30-ton combination shear and press is being produced by *Parker Manufacturing Co.*, Santa Monica, Calif. Mechanically operated, it shears, blanks, notches, punches, perforates, slots, pierces, lances, bends and forms sheet metal parts in single or multiple units, with one operator.

It needs no special foundation, has no overhanging parts, and requires 36- by 75-in. floor space. Because of its small size, it can be moved in and out of the production line as needed.

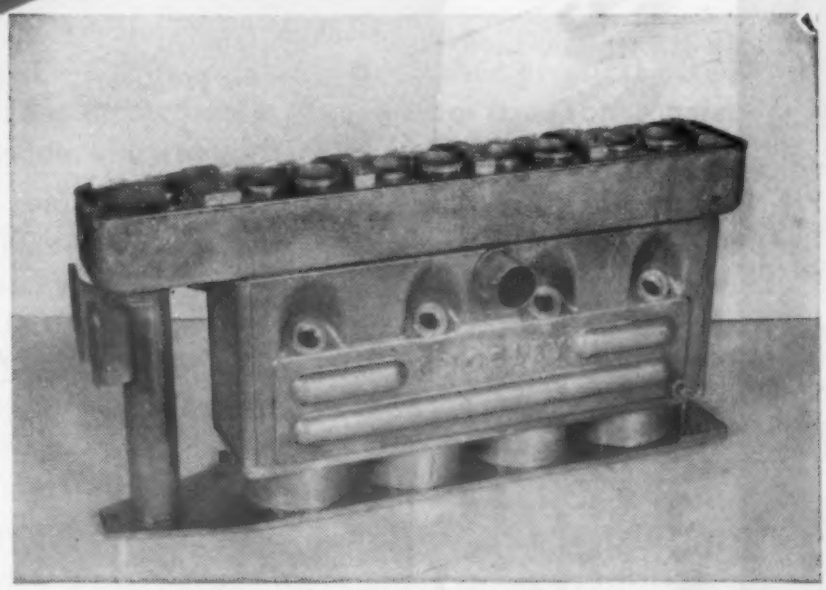


This press can be moved in and out of production line as needed.

The press is of all steel plate welded construction. The stroke is 2 in., as is the ram adjustment. Shut height is 10 in. The stroke is down, the adjustment up. Bed die space is 12 by 36 in.; ram die space is 10 by 36 in. Bed opening, 5 by 32 in. A 1½-h.p., 3-phase motor is furnished with each press, capable of producing 100 strokes per min. Bed is 32 in. from floor, overall height is 57 in.



CROSLEY ENGINE BLOCKS BRAZED in LINDBERG FURNACE



Over 120 separate parts brazed into a single unit in 1 operation

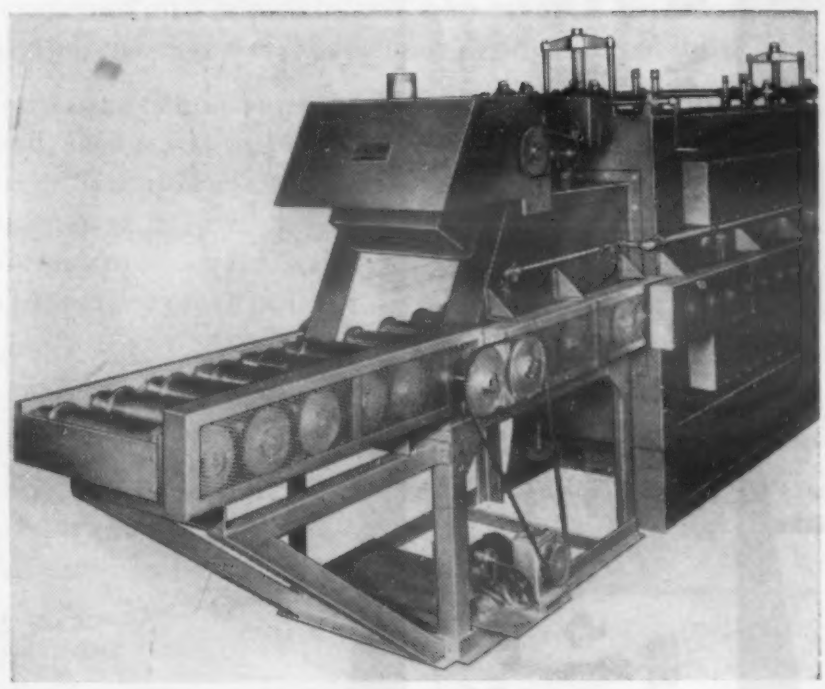
The brazed, all sheet-steel engine block used in the new Crosley car is outstanding among recent engineering developments.

In a single brazing operation, light walled alloy steel tubes and deep drawn steel stampings—over 120 in all—are brazed together in a Lindberg Roller Hearth Brazing furnace to form the Crosley engine block weighing only 14.8 pounds.

Completed engine block assemblies—4 to a tray, are automatically charged into the continuous Roller Hearth Furnace. The work, which at all times is protected by the Lindberg Hyen atmosphere against scaling or decarburization, first enters a preheating zone—then the brazing chamber, where the actual brazing takes place at 2060° F. From the brazing chamber, the blocks go to a slow-cooling zone which reduces the temperature to about 1500° F.

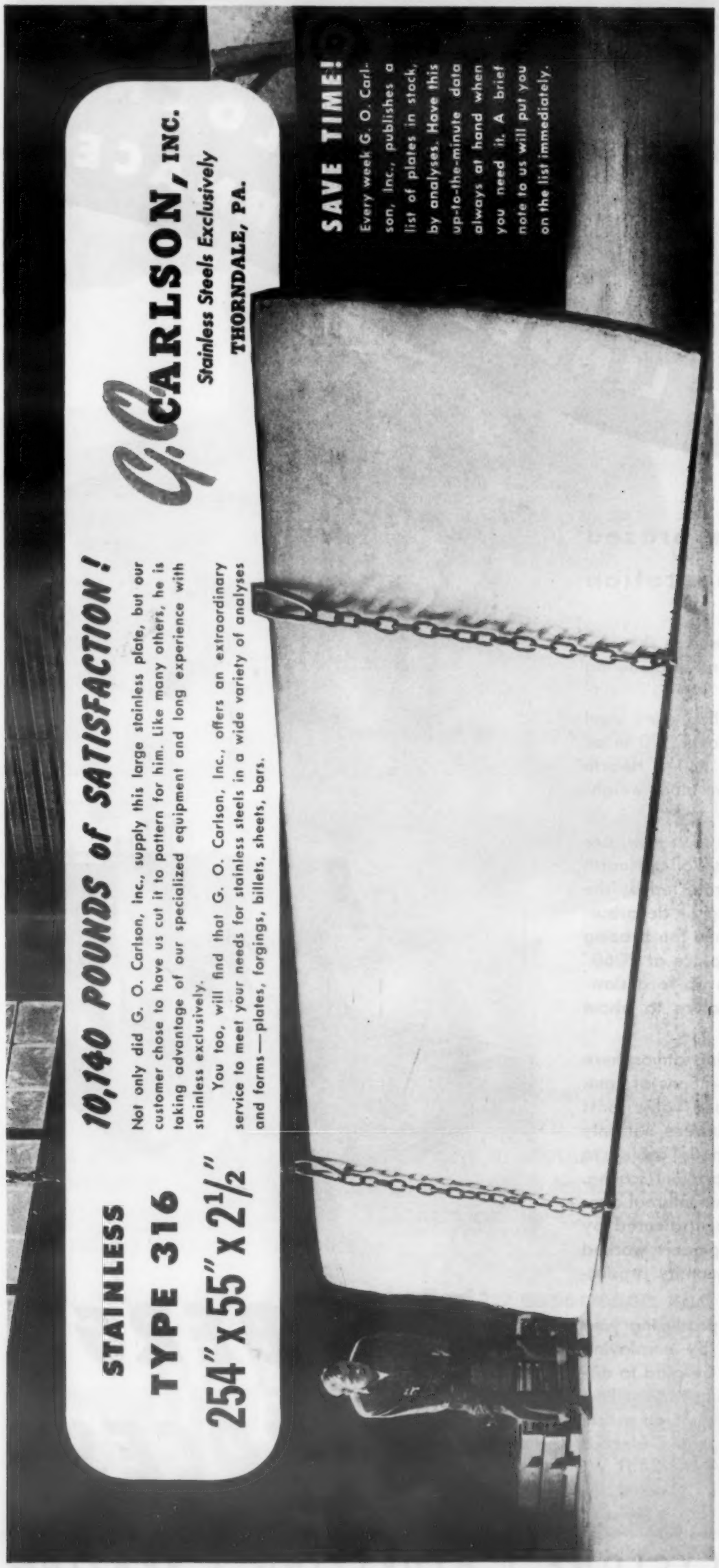
In the next zone, cooled Hyen Hydryzing atmosphere is forced over and through the block by means of fans. This atmosphere quenches the cylinders and valve seats to obtain necessary hardness. Thus the furnace not only brazes but also hardens. The block is finally cooled to about 200° F. in the Hyen atmosphere to prevent scaling. This process of assembling and hardening an internal combustion engine was invented and is being patented by Powel Crosley Jr.—and the Lindberg Engineers worked out a particular furnace, which permits quantity production.

Perhaps too, some of the problems of producing your product can be more efficiently solved by employing brazing methods. Lindberg Engineers will be glad to discuss various possible applications of brazing to your line. Write today for Bulletin 210 and a reprint of an article describing how the Crosley automobile engine block is made. LINDBERG ENGINEERING COMPANY, 2451 W. Hubbard Street, Chicago 12, Illinois.



LINDBERG FURNACES

SUPER-CYCLONE • CYCLONE • HYDRYZING • BRAZING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Not only did G. O. Carlson, inc., supply this large stainless plate, but our customer chose to have us cut it to pattern for him. Like many others, he is taking advantage of our specialized equipment and long experience with stainless exclusively.
You too, will find that G. O. Carlson, Inc., offers an extraordinary service to meet your needs for stainless steels in a wide variety of analyses and forms—plates, forgings, billets, sheets, bars.
STAINLESS
TYPE 316
254" x 55" x 2 1/2"

New Rubbers Are Oil Resistant and Non-Staining

Two new oil resistant rubbers have been introduced by *B. F. Goodrich Chemical Co.*, Rose Bldg., Cleveland 15, and are in commercial quantity production. Designated as Hycar OR-25 EP and Hycar OR-25 NS, these new rubbers have superior processing characteristics over the regular Hycar OR-25.

Hycar NS differs from Hycar EP only in that a different anti-oxidant has been added to the former, making it non-staining and non-discoloring. This is an outstanding advantage in the fabrication of light colored products where freedom from staining and discoloration are primary factors.

The principal advantages of these new Hycar rubbers over the regular process Hycar OR-25 are as follows: (1) Both band on the processing mill rolls very quickly, thereby decreasing mill mixing time. (2) Better extrusion characteristics due to less nerve and heat build-up. (3) Excellent high temperature mixing, such as Banbury operations. (4) Better fusion and mold flow characteristics. (5) Increased building tack for laminated products, such as frictioned stocks and calendered sheeting.

Preliminary investigation with these new rubbers indicate that to obtain an equivalent state of cure to the regular OR-25, the quantity of sulfur should be increased by 0.25 parts of sulfur to 100 parts of rubber polymer.

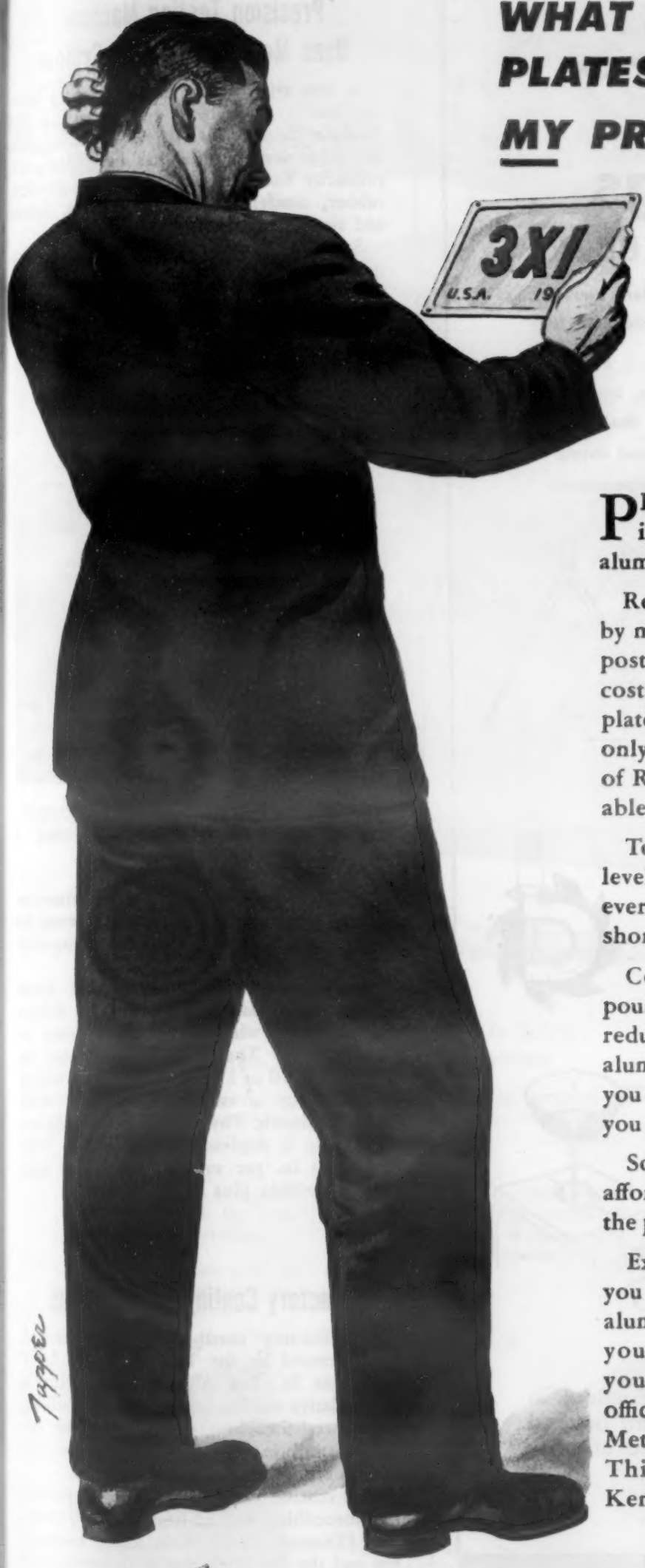
Machine Welds Small Parts Automatically

A new machine has been developed by *Tweezer-Weld Corp.*, 1060 Broad St., Newark, N. J., for the welding and shaping of light, small parts difficult to process manually. This equipment welds automatically by means of an electronic welding and timing device.

The assemblies or small parts are fed to a turret either by hand or automatically from a hopper. The equipment is particularly effective in attaching light wire from a spool to parts fed automatically. Before or after the welding process, components can be shaped so that the welded parts, when they leave the machine, are ready for assembly into the final product.

One of the chief uses of the automatic welder is the welding of tabs to radio tube cathodes. The machine can produce approximately 3000 cathode assemblies per hr. without the use of an arbor. It will handle round and flat cathodes from 0.020 in. O.D. to 0.125 in. O.D., lengths from ⅜ in. to 2½ in., and tab wire as fine as 0.002 in. by 0.006 in.

With adjustments, the equipment will also weld bi-metal strip to a two-piece lead, forming the bi-metal and cutting the bi-metal to length. In the production of fluorescent light starter stems, the equipment will automatically trim off starter stem leads and will form, weld and cut the bi-metal.



WHAT HAVE ALUMINUM LICENSE PLATES GOT TO DO WITH MY PRODUCT?

PLENTY, because here is another practical case history illustrating how a change from traditional materials to aluminum lead to both lower costs and an improved product.

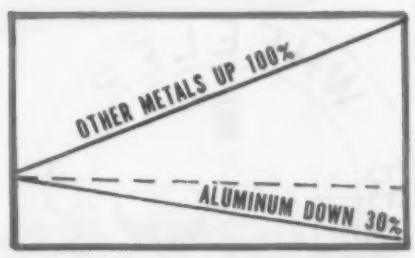
Reynolds Aluminum for license plates is now being used by many states. Where these lightweight plates are mailed, postage savings alone can mount up to 6¢ per set. Painting costs are cut an estimated 2½¢ per set because aluminum plates, unlike those of steel, require painting of the numbers only. Rust can never disfigure these plates and, when made of Reynolds embossed aluminum sheet, they offer remarkable visibility without any glare.

Today's cost of Reynolds Aluminum is well below prewar levels. With 3 times more metal surface for production in every pound of aluminum you buy—there's no need to let shortages of other metal keep your product out of the market.

Consider the advantages of more workable metal per pound, less waste in production, no cost for rust-proofing, reduced shipping cost, reduced labor expense because aluminum is light to handle and faster in fabrication—then you can appreciate just how much more aluminum offers you plus many more points to please and sell your customers.

So the only cost in connection with aluminum you can't afford is the cost of having your competitor discover first the production and sales advantages of Reynolds Aluminum.

Experienced technicians from Reynolds will gladly advise you how the correct type of aluminum can be adapted to your production. Contact your local Reynolds field office or write to Reynolds Metals Company, 2560 South Third Street, Louisville 1, Kentucky.



The price of aluminum has gone down 30% since Reynolds became a primary producer in 1939.

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REYNOLDS METALS

REYNOLDS *Lifetime* **ALUMINUM**

Permanent

Mold Castings

by WHEELER

Wheeler is organized to serve industry's need for modern knowledge on the permanent mold process and its application to up-to-the-minute production problems. . . .

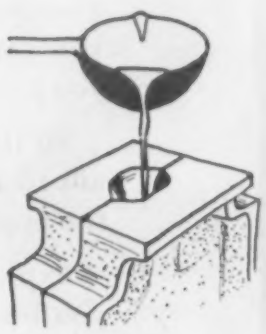
Materials cast are aluminum alloys, magnesium alloys, bronzes, cast iron, zinc and lead. The organization covers design of products for the process, the manufacture of the tools, and obtaining optimum production with the aid of our skilled and experienced service engineers.

Design . . .

Complete design service covering design of new molds—redesigning of existing machine parts for easy casting—Product design a specialty.

Manufacture . . .

Molds manufactured to your exacting specifications — Completely equipped with operating mechanisms and work stands if desired.



Experimental . . .

Faulty or inefficient molds tested and corrected in our development foundry. . . . We can supply new molds broken in, ready for production.

Wheeler Service
Both technical and practical, is of the highest standard backed by an excellent record of work accomplished.

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MAIN ENGINEERING OFFICE & EXPERIMENTAL FOUNDRY
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HOLYOKE, MASS.

Precision Testing Machine Uses Mechanical Screw System

A new type of Baldwin-Tate-Emery testing machine has been announced by the *Baldwin Locomotive Works*, Philadelphia 42. The new machine has been designed primarily for precision testing of plastics, rubber, nonferrous metals, textiles, fibers and similar materials.

Some of the features of the machine are its continuously-variable 400:1 positive

This precision testing machine has 5000-lb. capacity and can be used for testing a variety of materials.

speed range; horizontal rigidity; elimination of backlash; and its high accuracy even in the lowest ranges. Its maximum capacity is 5000 lb.

This machine uses a mechanical screw system. The loading crosshead is driven by two screws which pass through nuts in the crosshead. These screws are rotated by a 1 to 1, or 10 to 1 gear transmission which is driven by a variable-speedmotor with General Electric Thymotrol control. Speed of loading is steplessly variable from 0.05 in. to 20 in. per min., and can be held constant within plus or minus 2%.

Refractory Coating for Furnaces

A refractory coating named Vitroseal, manufactured by the *Whitman Co.*, 1407 Esperanza St., Los Angeles 23, Calif., is an insulative coating for preventing spalling action, resisting heat penetration and decreasing carbon, slag and clinker adherence in fire boxes, furnaces and crucibles.

The coating forms a semi-glazed protective monolithic wall of from 8.5 to 9 hardness (Diamond is 10 Mohs scale) between fire and the fire brick that is impervious to heats up to 3390 F, and it withstands the destructive effects of flame impingement and abrasion.

This glazed coating is said to speed heat-up time due to reflection and decrease heat loss through joints. It can be applied by either brush or spray. It is shipped to the user in powder form, and water is added before application.

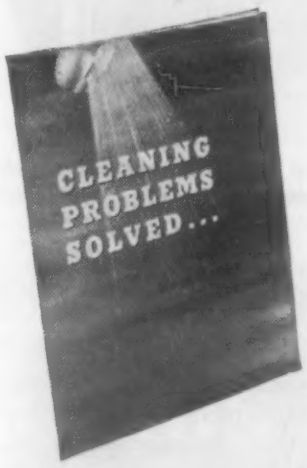
Versatility IN CLEANING HEAT TREATED PRODUCTS

In the manufacture of complex mechanical and electrical devices, American Bosch Corporation, Springfield, Mass., encountered the problem of cleaning thousands of different metal parts. Since sizes and shapes varied considerably existing cleaning equipment was unable to handle the large and diversified volume of pieces.

This progressive organization investigated various types of blast cleaning equipment and decided upon an airless WHEELABRATOR MULTI-TABLE. In operation the machine was found to be most practical for general deburring and to impart an excellent pre-plating surface to a wide variety of parts.

How American Bosch Corporation Is Using This Versatile Blast Cleaning Machine

- Removing heat treating "skin" from hardened fuel injection parts prior to grinding.
- Cleaning heat treated parts to prepare them for cadmium and zinc plating.
- Cleaning of pieces prior to nitriding to obtain uniform nitriding.
- Preparation of magnesium and aluminum parts for anodizing and dichromating.
- Determining varying zones of hardness in sectioned forgings, bar sections, etc., after heat treatment.



Write for the latest treatise, "CLEANING PROBLEMS SOLVED For Heat Treating and Forging Plants." Learn TODAY how AMERICAN can solve YOUR cleaning problem.

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WHEELABRATOR AND EQUIPMENT CORP.

(Formerly American Foundry Equipment Co.)

538 South Byrkit Street, Mishawaka 7, Indiana

Representatives In Principal Cities

WORLD'S LARGEST BUILDERS OF AIRLESS BLAST EQUIPMENT

Producers of

Metal Powders

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THE AMERICAN METAL CO., LTD.

61 BROADWAY, NEW YORK 6, N. Y.

for flash plating that sticks

METSO

Be sure that your cleaner contains a PQ silicate detergent such as Metso Granular or Metso 99. Thus you get the benefit of balanced silica-alkali content, which brings about spontaneous emulsification of oily or greasy films. And then a special property of Metso is its efficient suspending action so that the dirt is kept free of the clean metal.

It pays to be informed about silicate's ability to deliver chemically cleaned surfaces. Write for additional information.

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metso® cleaners

PQ SILICATES FOR FABRICATING METAL CLEANERS

Metso Granular
($Na_2SiO_3.5H_2O$) Sodium Metasilicate. Free-flowing, white granular product.

Metso 99
($Na_3HSiO_4.5H_2O$) Sodium Sesquisilicate. White, granular, free-flowing.

G-C Brand
($Na_2O.2SiO_2$) Powdered Sodium Silicate. Hydrated, alkaline. Readily soluble.

SS-C-Pwd
($Na_2O.2SiO_2$) Anhydrous Silicate. Slowly soluble. Ground to pass 65 mesh.

PQ®

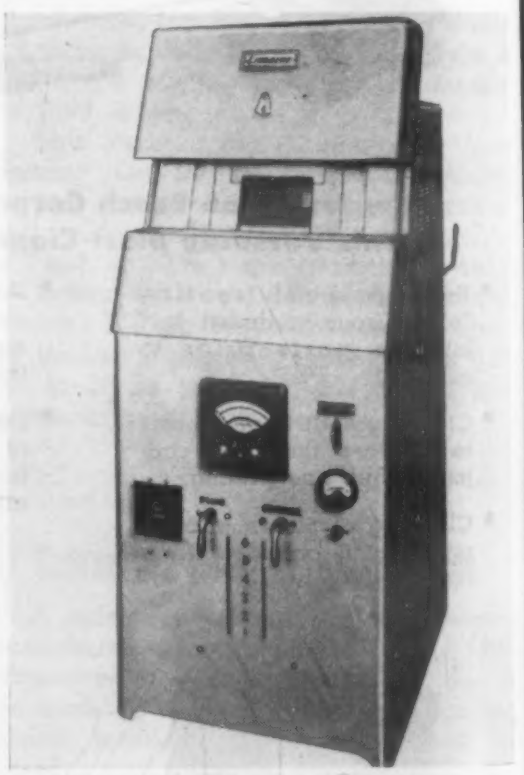
Sodium Sesquisilicate U S. Pat 1948730, 2145749 Sodium Metasilicate U.S. Pat 1898707

● A complete line of enclosed thermocouples for general foundry use interchangeable with existing equipment has been announced by the *Industrial Instrument Service Co.*, 2785 Slauson Ave., Huntington Park, Calif. These thermocouples are constructed in one piece in any length or shape. They are supplied as standard in 18- and 24-in. lengths, straight or with 45- or 90-deg. bends using 16-gage matched chromel-alumel elements. Shorter lengths also are available.

Laboratory Furnace for Temperatures up to 3000 F

A new box-type laboratory furnace with temperatures up to 3000 F top heat, and for continuous operation as high as 2500 F, has been developed by *Lindberg Engineering Co.*, 2444 W. Hubbard St., Chicago. This self-contained unit may also be used as a muffle furnace, or with carbon blocks for nonoxidizing atmospheres.

The 3000 F top heat capacity provides heat at any lower level more quickly. The furnace has ten silicon carbide "Globar" heating elements. Furnace temperatures are



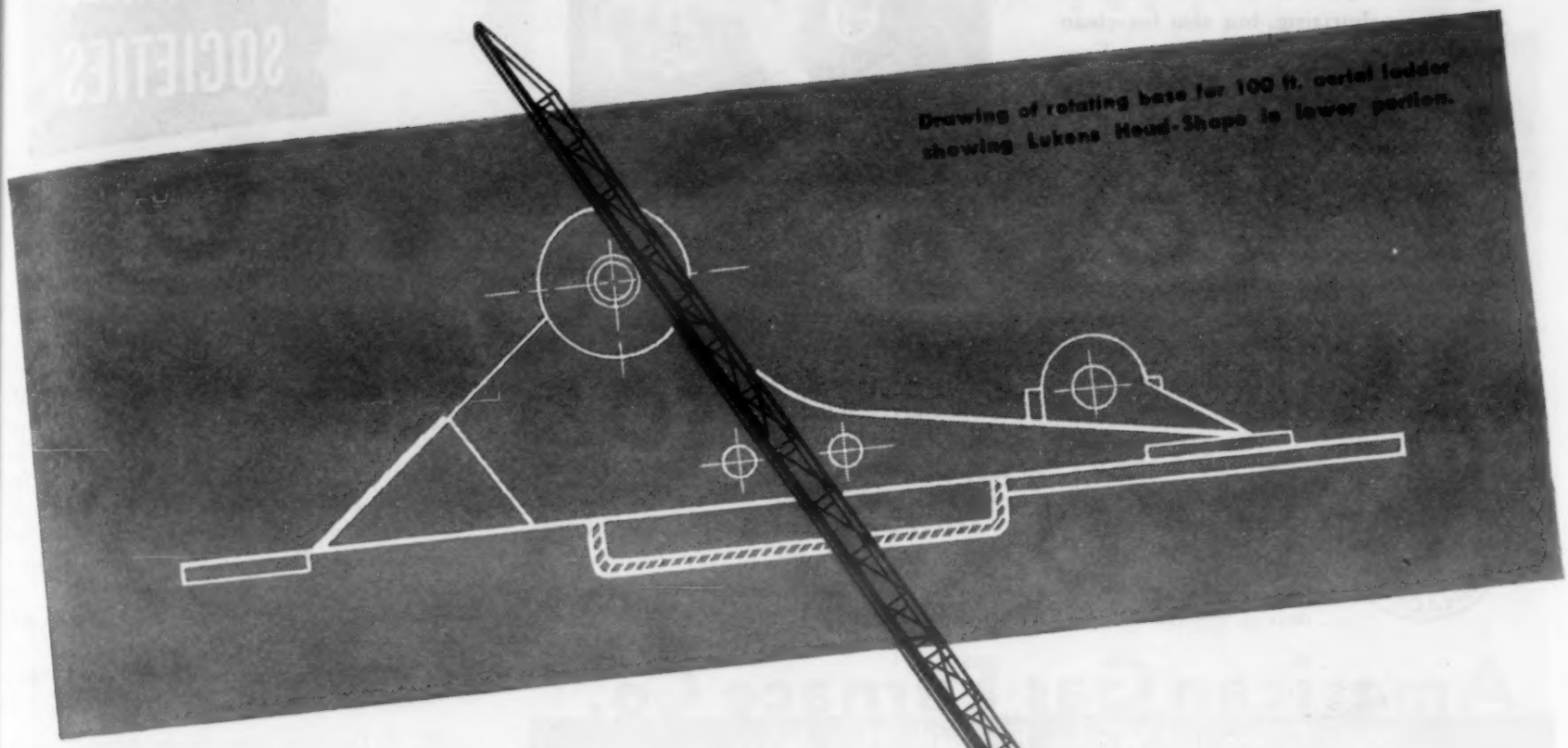
The furnace temperatures are regulated by an indicating-controlling pyrometer with electronic circuit.

regulated by an indicating-controlling pyrometer with electronic circuit.

Model G-10 is designed for operation on 230 v., 60 cycle, single phase. The variable voltage transformer, which is contained within the unit, has a capacity of 8 kw. and is used in conjunction with the two tap switches, each of which have six control points for voltage regulation.

LUKENS HEAD-SHAPES

. . . Rotating bases for Aerial Ladders



The builder of this equipment saved time and money by using a Lukens Head-Shape in the rotating base on which the fire ladder turns. He thus eliminated the need for producing the part in his plant and was able to start right in with assembly.

Made from rolled steel plate, these Head-Shapes assure strength and dependability for such important parts. Accurate in form, they require only a minimum of machining.

Many manufacturers are similarly bypassing a time-consuming forming operation by starting with Lukens Head-Shapes, thereby releasing machines and manpower for other work.

May we help you design Lukens Head-Shapes into your products? Write Lukens Steel Company, 419 Lukens Building, Coatesville, Pennsylvania.

This fire truck and ladder are the products of American-La France-Foamite Corporation.

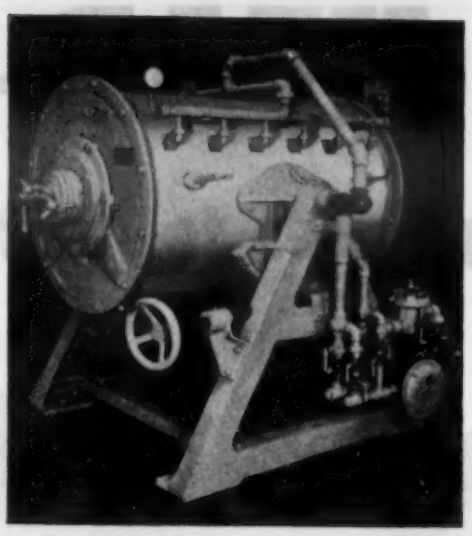
LUKENS HEADS FOUR INCHES TO OVER EIGHTEEN FEET IN DIAMETER

ROTARY GAS CARBURIZERS

A "First" by A.G.F. Co.

Versatility is the outstanding characteristic of AGF Rotary Gas Carburizing Furnaces, which may be used not only for carburizing, but also for clean hardening, normalizing, annealing, and other general or atmospheric work without modification to the furnace of any kind.

Uniform heating of the work is assured by the gentle mixing produced by the rotary action of the retort, which is heated by numerous carefully distributed and balanced gas burners. Carburizing or atmosphere gas is introduced through a simply-designed, trouble-free connection.



Charging and discharging of the work is accomplished by means of a tilting feature, which is power-driven on the larger models. The retort remains within the heat at all times.

The furnace shown above is the latest, improved AGF Rotary Gas Carburizer, batch type, with new maintenance-free roller bearing retort support.

AGF gas carburizing equipment also includes Continuous Rotary Furnaces and Vertical Retort Carburizers. Write for literature.

American Gas Furnace Co.

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News of...

ENGINEERS COMPANIES SOCIETIES

Engineers

Thomas G. Digges has been appointed chief, Thermal Metallurgy section, National Bureau of Standards, succeeding D. J. McAdam, who retired August 31, 1947. Mr. Digges has been a member of the metallurgy division since January, 1920. He has specialized on machinability, tool steels and cutting tools, thermal analysis and critical-cooling rates of high purity alloys of iron and carbon. During the war he studied boron as an alloying element of steel and investigated decarburization during the manufacture of alloy steel tubing for aircraft. He has been an author of several technical papers.

W. E. Day has been made director of research for Mack Trucks, having been its chief metallurgist. He instructed in metallurgy at Harvard and later set up the first chemical laboratory for Mack Trucks, which has grown to one of the best equipped and most elaborate in the automotive industry. He developed a cheap and superior aluminum solder, and in his early career developed aluminum, chromium and copper alloys that are still in use. He has been active in several technical societies.

Dr. Thomas P. May has joined the corrosion engineering section, Development Research Div., International Nickel Co., Inc. at New York. He was formerly with the Chemistry Div., U. S. Naval Research Laboratory, Washington, D. C., serving as head of the corrosion section. He belongs to three societies and has authored several technical papers.

Oliver Smalley, president Meehanite Metal Corp., has been named to the advisory council for science and engineering at the University of Notre Dame.

Andrew Van Echo, formerly technical service representative and chief inspector, Joslyn Stainless Steel Co., Fort Wayne, Ind., is now metallurgical engineer, William E. Pratt Mfg. Co., Joliet, Ill. He has been in the metallurgical department, South Works, Carnegie-Illinois Steel Corp., and later was associated with the Manhattan project at the University of Chicago.

J. F. McQuillan has been appointed superintendent of the Whiting, Ind. plant, Federated Metals Div., American Smelting & Refining Co. *A. S. Wigle,* former plant superintendent at Whiting, has been made general superintendent of all Whiting operations. Mr. McQuillan has been super-

WHICH ALUMINUM CASTING IS BEST FOR YOU?

ASK ALCOA . . WE MAKE ALL THREE!

Ask us which type of Aluminum Casting is best for your product . . . and you get a frank, technically-sound answer. We make all three types, have no special bias in favor of any one of the three. Our job is to see that you use the casting that's best for your product . . . and for your production cost figures.

Each type of Alcoa Aluminum Casting —sand, permanent mold, and die—has its points. Your product may require a combination of two types, or even all three.

Our engineers and our 59 years of aluminum know-how are at your service to help you get the most from Alcoa Aluminum Castings. ALUMINUM COMPANY OF AMERICA, 2162 Gulf Bldg., Pittsburgh 19, Penna. Sales offices in leading cities.

MORE people want MORE aluminum for MORE uses than ever

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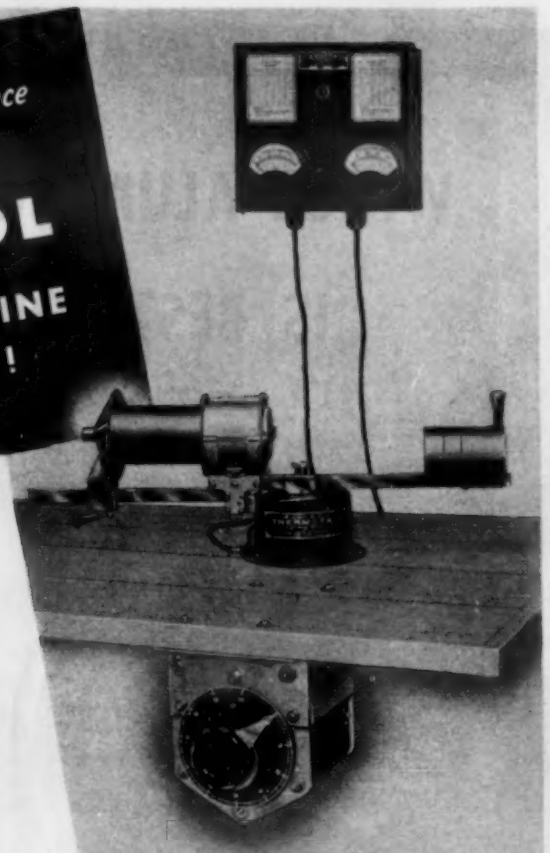
THE CASTING MACHINE WITH A MEMORY!



Successful casting *demands* accurate control! Precision casting by the lost wax process with THERMOTROL gives you this... and *MORE. Even a novice can be trained in less than one hour... to make perfect casts!*

Our latest publication, "Precision Casting by THERMOTROL," not only gives you complete details on this amazing casting machine, but is also chock-full of other interesting information on Precision Investment Casting!

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EST. 1918

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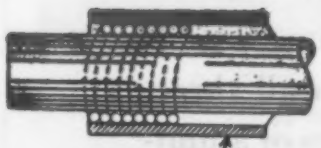
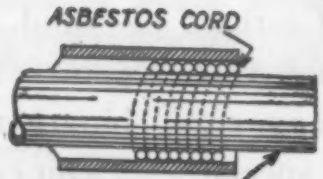
VITREOSIL (Vitreous Silica)

TUBES

FOR GAS ANALYSES



IRON PROTECTOR



● Unsuitable, unprotected iron tubes may nullify your gas sampling, introduce serious errors. Vitreosil (Vitreous Silica) tubes avoid all danger of contamination. They cannot rust. They are indifferent to thermal shock; chemically inert, non-porous. When properly protected, vitreosil tubes give long life. May be water-cooled.

● The use of Vitreosil for Gas Sampling is fully covered in Vitreosil Bulletin No. 3. We will be glad to send you a copy; also to answer any specific questions you may care to ask us.

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Write for Bulletin 3.

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News of...

ENGINEERS COMPANIES SOCIETIES

intendent at both the Perth Amboy and Pittsburgh plants.

Norman L. Deuble has joined the metallurgical engineering staff of the Climax Molybdenum Co. For the past four years he has been with the M. W. Kellogg Co., Jersey City, N. J., in charge of special processes and of work in the high temperature laboratory. He spent 20 years in alloy steel metallurgy with the Republic Steel Corp. and during the war was in the Steel and Aircraft Production divisions, WPB.

E. L. Ramsey, who retired recently as superintendent of steel production, Wisconsin Steel Co., has become a technical consultant with Miller & Co., Chicago. His experience has been with U. S. Steel Corp., Republic Steel Corp., Mesta Machine Co. and Wisconsin Steel Co., and he has been a leader in development of steel processes by open-hearth methods. He will continue development of practices for new alloys and deoxidizers.

Dr. John R. Nielsen has been appointed associate professor of metal science in the New York University College of Engineering. He has conducted considerable research in crystallography, X-ray metallography and the physics of metals. Previous connections have been with Philips Laboratories, Inc. and International Nickel Co. He is a member of several technical societies and author of several papers.

Prof. Peter E. Kyle is the first occupant of a new chair at Cornell University, an endowed professorship of metallurgical engineering named for Francis Norwood Bard, owner of the Barco Mfg. Co. of Chicago. The Cornell school of chemical engineering has been renamed as the school of chemical and metallurgical engineering. Prof. Kyle taught courses in materials and metals processing at Massachusetts Institute of Technology. During the war he was a consultant on materials and production methods. He has been active in technical society work.

Dr. Achille Capecelatro has been appointed consulting engineer on product design for the C-Eight Laboratories, Newark, N. J. He is an assistant professor of physics at the Newark College of Engineering. He is responsible for the Navy's new standard compass that is not susceptible to degaussing coil errors and for a novel production method for testing permanent magnets.

Earl Blaine, formerly chief inspector, has been appointed assistant works manager, Budd Co. *John Darrah,* formerly assistant to Mr. Blaine, has become chief inspector. *Ernest R. Schmidt* was recently made plant manager of the Hunting Park plant.

Warren R. Tucker, vice president, Commonwealth Engineering Co., Dayton, Ohio, has been elected to fill the newly-created post of vice president in charge of engi-

Time Presents a Strong Case for Plastics

When Consolidated-molded, the item illustrated satisfactorily met the following requirements:

- ✔ High surface polish
- ✔ Clean-cut fluting
- ✔ Rich, stable color
- ✔ Structural strength
- ✔ Lightweight
- ✔ Dimensional stability
- ✔ Precision molded slot to engage force-fit metal hinge assembly

End-Use Assembly

Larger illustration (upper left) shows plastic watch box frame as compression molded of urea formaldehyde by Consolidated Molded Products Corp. Above: Complete watch display case assembly as produced by Arrow Manufacturing Company, Hoboken, N. J., for the Bulova Watch Company's 21 Jewel "Excellency" Series.

Simple things, done well, are good teachers. They pave the way to more difficult things, done equally well—just as simply! Through experience and sound knowledge the good molder is able to organize simple procedures for each specific *must*. When the end-use function is known, the proper material selection is simple. When a high surface polish is desired without recourse to post-molding operations, a quality mold finish attains the objective . . . simply, economically.

Here in the above-shown *case for plastics* it was also necessary to incorporate a top-face slot which would securely anchor the manufacturer's specially formed, velvet-wrapped cover. This step, too, was simple—the accurate die construction producing a precision-molded opening permitted speedy assembly in one easy operation. Meeting the huge quantity requirements of so famous a watchmaker was simply a matter of designing a six-cavity mold for mounting in a press of suitable capacity.

The case for plastics always reduces to the simple one of "know-how" . . . the right material, in the right place, rightly used. Since 1874 Consolidated has practiced high quality custom molding. Our cumulative experience with all plastic materials and methods is your guarantee of moldings that are modern in design . . . properly processed . . . functionally correct. When your problem is one of plastics parts or products of precision and quality, the answer can be simple: Call Consolidated!

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MOLDED PRODUCTS *Corporation*
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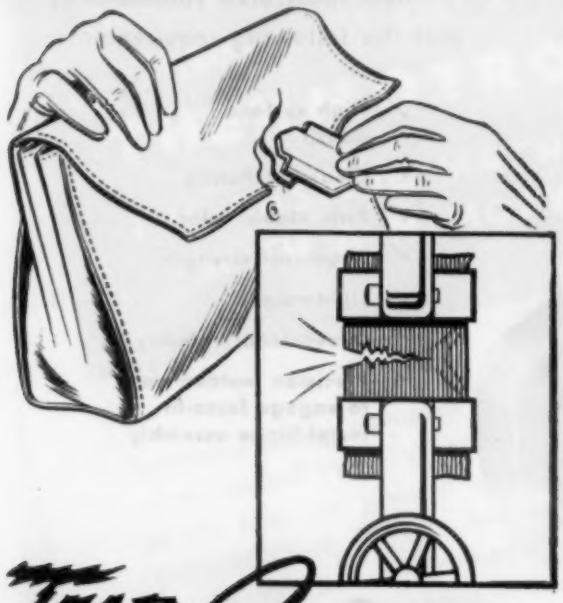

TEAR Resistance

*Scott Tester Model J tests for tear, elongation and tensile strength of plastic films, metal strip, wire, paper, leather, textiles, etc., with capacity up to 500 lbs. Also provides burst test. World-standard tests; "picturized" graph results.

"Adequate Testing Always Pays"

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Standard of the World

News of...

ENGINEERS COMPANIES SOCIETIES

neering and research, Hydraulic Press Mfg. Co.

George W. Frick, for many years with the tool and die industry, has been made special representative in sales development by Latrobe Electric Steel Co. For many years he was with the Firth-Sterling Steel & Carbide Corp. More recently he founded the Carbide Die & Mold Co.

Ernest L. Gartner, manager, Metal & Ore Div., Du Pont Co.'s Grasselli Chemicals Dept., retired Dec. 1 after 43 years with the company. He is an authority on zinc and other metals. During the war he was a member of WPB's advisory committees on zinc and cadmium.

Arthur Sprague Osborn has been appointed to the staff of the Midwest Research Institute, Kansas City 2, Mo., and will be assigned to work in mechanics and electro-mechanical design and analysis. Other connections have been with the Minneapolis-Honeywell Co. and Aireon Mfg. Co.

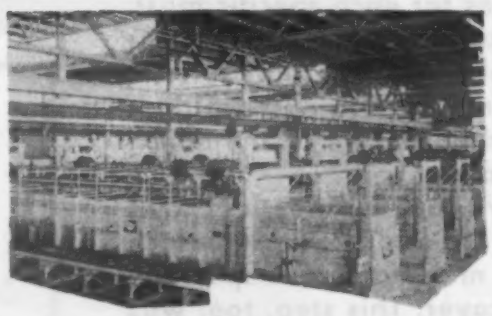
W. G. Miller has been made assistant to the works manager, Buffalo division, Westinghouse Electric Corp. During the war he was methods engineer and staff supervisor in the Canton, Ohio, ordnance plant.

Robert B. Lewis, chief engineer, Tinius Olsen Testing Machine Co., for 35 years, died Oct. 24 at the age of 73. Numerous patents relating to physical testing machines and equipment were issued to him. He was quite active in several engineering societies.

Companies

The first German reparations plant offered to United States industry involves an aluminum foil plant, successfully bid for by *Permanente Metals Corp.* It will probably be located in the state of Washington where the company now operates three other aluminum plants. The new plant will involve an expenditure of $1,000,000 and will be the only aluminum foil plant west of the Mississippi. Located at Teningen, Baden, Germany, the dismantled plant will be loaded on barges at Kehl and transported down the Rhine to a North Sea port. Prior to the war the plant exported foil to the United States and throughout the world.

Crosley Motors, Inc., producer of light weight, low cost passenger cars and trucks, has started an expansion program to increase its Cincinnati engine plant facilities



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FOR MODERN PLANT OPERATION

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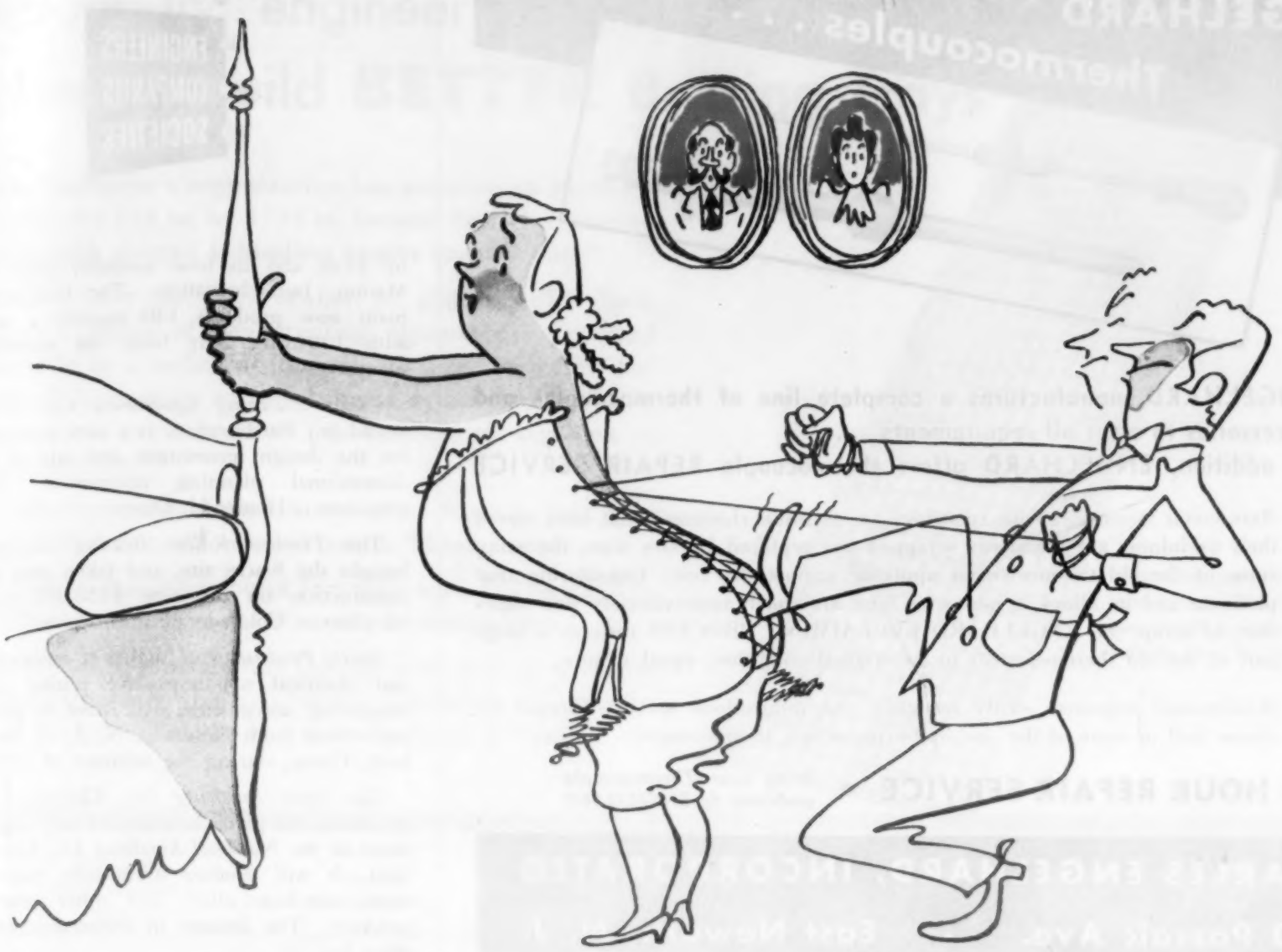


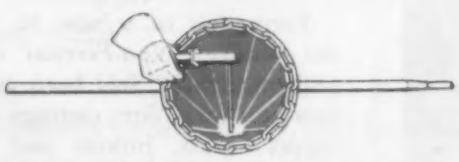
The Case of the Controlled Contours

Contour control is most important . . . especially to achieve good results in welding operations!

McKay Electrodes have the particular properties needed for proper regulation of bead contour, as well as weld metallurgy and arc action.

With McKay Electrodes, the operator lays down beads which are the exact size and shape required by the job. The weld metal is metallurgically sound, free from slag inclusion and has the correct mechanical properties.

Thus McKay Electrodes assist in producing stronger structures with less weld metal and lower finishing costs. *See for yourself. Test McKay Shielded-Arc Electrodes on your next job.*



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Write or phone for detailed information on the complete line of McKay Shielded-Arc Electrodes. Our Technical Staff can recommend the electrodes best suited to your needs.

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Researched, Developed and Manufactured to fill Industry's Requirements for Dependable Electrodes

ENGELHARD Thermocouples . . .

ENGELHARD manufactures a complete line of thermocouples and accessories to meet all requirements . . . . . .
In addition, ENGELHARD offers thermocouple REPAIR SERVICE

- Rare metal thermoelements (platinum vs. platinum-rhodium) that have served their usefulness are commonly scrapped and replaced by new wire, the scrap value of the old thermoelement applying against the cost. Considering that platinum and its alloys in new wire form are worth approximately four times that, as scrap, the ENGELHARD RECLAIMING PROCESS restores a large part of the old thermoelement to its original condition, equal to new.
- Maintenance engineers easily recognize the tremendous savings effected by almost half or more of the cost of buying a new thermocouple.

48 HOUR REPAIR SERVICE • *Bring your Thermocouple problems to ENGELHARD*

CHARLES ENGELHARD, INCORPORATED
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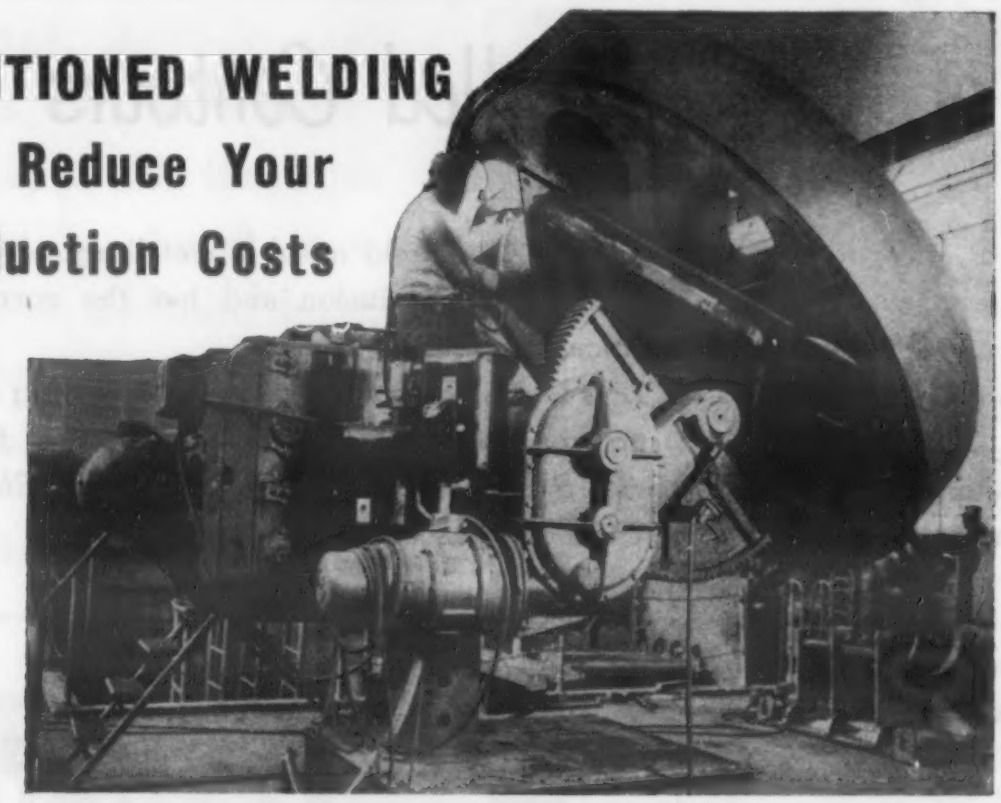
POSITIONED WELDING Can Reduce Your Production Costs



Because C-F Welding Positioners make every weld a downhand weld, your welding time and cost is cut to a minimum. Positioned welding permits use of larger electrodes—fillets of correct width and depth can be laid in one pass, with resulting time and material saving PLUS better welding. C-F Positioners with Variable Speed table rotation in any range from 0 rpm and up provide greater flexibility of positioner use in all types of automatic or hand welding. Like all C-F Positioners, these power operated models tilt 135° from the horizontal and full 360° table rotation is possible at any angle.

Investigate the definite cost-saving advantages of C-F Power or Hand Operated Positioners. All models have either variable or constant speed control of table rotation. Write for Bulletin WP 22.

CULLEN-FRIESTEDT COMPANY
1314 SOUTH KILBOURN AVENUE CHICAGO, ILL.

News of...

ENGINEERS COMPANIES SOCIETIES

by 21% and its final assembly plant at Marion, Ind., by 40%. The Cincinnati plant now produces 140 engines a day, with 120 cars daily from the assembly plant.

Visual Planning Equipment Co., 6247 Broad St., Pittsburgh 6, is a new company for the design, promotion and sale of 3-dimensional planning equipment. The president is Homer H. Dasey.

The *Timken Roller Bearing Co.* has bought the 8-acre site, and taken over all construction on the new $150,000 rock bit plant at Colorado Springs, Colo.

Sperry Products, Inc., maker of supersonic and electrical non-destructive testing and measuring instruments, will move its plant and offices from Hoboken, N. J., to Danbury, Conn., during the summer of 1948.

The *Apex Smelting Co.*, Chicago, has purchased the plant, laboratories and equipment of the *National Smelting Co.*, Cleveland. It will produce aluminum, magnesium, zinc-base alloys and other related products. The change in ownership took effect Jan. 1.

Leeds & Northrup Co. has purchased a building at 34 E. Logan St., Philadelphia, one block from its main plant, adding 11,000 sq. ft. of space.

The first aluminum sheet ever rolled with modern equipment in Mexico is now coming off a newly-completed sheet mill near Mexico City. The sheet is fabricated from Canadian ingot produced at Arvida, Quebec. A foil mill is now nearing completion and plans call for an aluminum paste plant for operation in 1948.

Reeve Hoover has been elected president of *Commercialores, Inc.*, which was formed last March to develop a large kyanite deposit in South Carolina. Kyanite is a silicate of alumina widely used in superduty refractories and in other branches of the ceramic industry. A plant is being constructed near Clover, S. C.

Formation of a new St. Louis foundry, the *Mullins Non-Ferrous Castings Corp.*, 1800 S. 18 St., has been completed. It is now turning out castings of aluminum, copper, brass, bronze and like materials, ranging from 1 oz. to 400 lb. Capacity is 10,000 lb. of aluminum or 25,000 lb. of brass daily. The new concern purchased the property and complete foundry of the Acme Brass Foundry.

Owens-Corning Fiberglas Corp. is establishing a Fiberglas textile division at 16 E. 56 St., New York, while a Fiberglas textile product development laboratory is being transferred from Newark, Ohio, to the plant in Ashton, R. I.

Allis-Chalmers Mfg. Co., Milwaukee, is

Rolock, Inc. engineer tells

How to Build **BETTER** Brazing Trays

"Our customer's organization has adopted as standard design the 1/4 in. by 1/16 in. Inconel flat wire brazing trays with riveted U-binding corner construction."

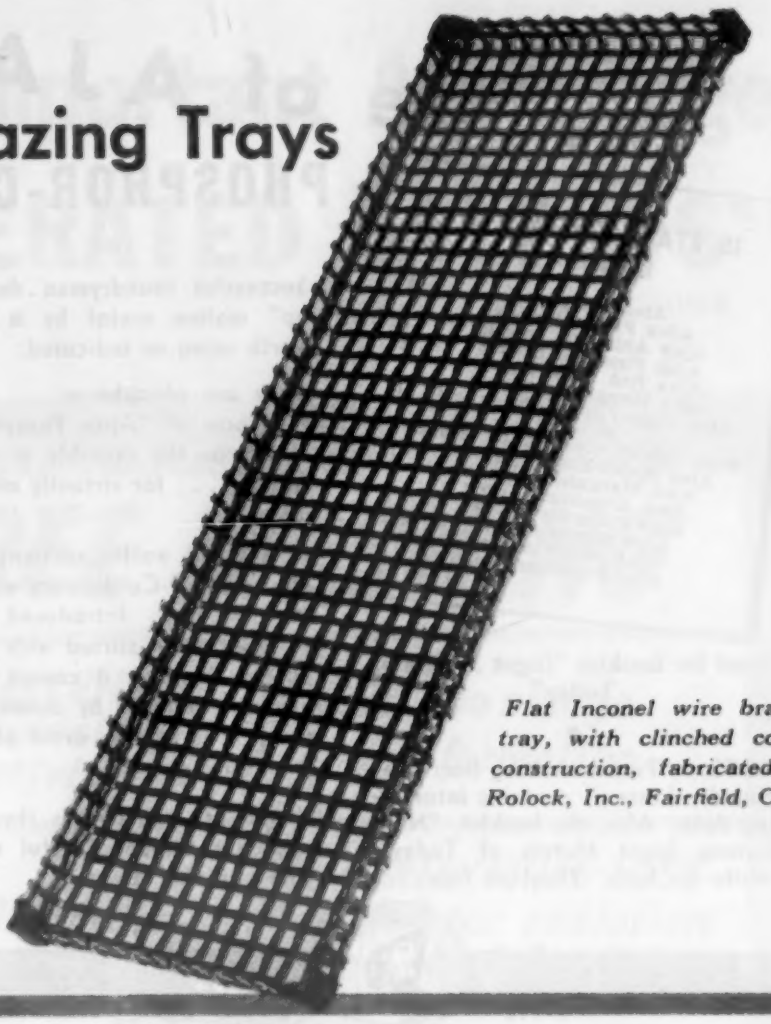
That is what Mr. C. H. Weber, Jr., engineer of Rolock, Inc. – builders of heat-treating equipment – reported recently in a technical journal. To determine how the cost of large-scale copper brazing operations could be reduced, a manufacturer undertook a service test of brazing trays.

The test trays were fabricated by Rolock, Inc. Two types of construction were tested. These were:

1. .120 in. diameter round Inconel* wire, 1/2 in. x 1/2 in. center-to-center mesh. All-welded construction.

2. 1/4 in. x 1/16 in. flat Inconel wire, 3/4 in. x 3/4 in. center-to-center mesh. Riveted U-binding on corners.

Mr. Weber tabulates the test results as follows:



Flat Inconel wire brazing tray, with clinched corner construction, fabricated by Rolock, Inc., Fairfield, Conn.

Service life. Hours exposed at 2050°F.	Mesh Specifications	No. of times exposed at 2050°F.	Observations after service
29.9	round Inconel wire	225	No scaling; material ductile, several cracked corner welds (no corner clips). Tray could probably be repaired for further service.
104**	flat Inconel wire	742**	Still in service. Some wires have warped.

**Note that these figures are incomplete since the tray was still in use at the time of reporting.

It is clear from these figures that the flat Inconel wire construction with no welding gave more than 3 times the service of the welded round wire type. The promise apparent in the test results has been borne out in practise. Mr. Weber reports:

"The manufacturer, with many such trays in service, has reported substantial annual savings in brazing furnace operating costs."

This is a typical INCONEL story! If you have heat-resisting equipment problems, it will pay you to investigate Inconel's unusual combination of properties without delay.

*Reg. U. S. Pat. Off.

For further information, write for your copy of "For Long Life at High Temperatures." It is free.

SAVE WITH INCONEL THERMOCOUPLE PROTECTION TUBES

These strong, shock-and-corrosion resistant seamless Inconel tubes can be used in sulfur-free atmospheres up to 2200° F. Your supplier stocks them in various sizes and lengths.

THE INTERNATIONAL NICKEL COMPANY, INC., 67 Wall Street, New York 5, N. Y.

INCONEL* ...for long life at high temperatures

(80 NICKEL - 14 CHROMIUM)

the use of AJAX PHOSPHOR-COPPER

15 STANDARD ALLOYS BY AJAX

Ajax Tombasil
Ajax Plastic Bronze
Ajax Anti-Acid Bronze
Ajax Phosphor Bronze
Ajax Red Brass Ingots
Ajax Manganese Bronze
Ajax High-Tensile Manganese Bronze
Ajax Golden Glow Yellow Brass
Ajax Nickel-Copper 50-50%
Ajax Manganese Copper
Ajax Aluminum Alloys
Ajax Phosphor Copper
Ajax Silicon Copper
Ajax Nickel Alloys
Ajax Phosphor Tin

Send for booklet "Ingot Metals of Today"

•

NOTE: * "Proper Melting Decreases Foundry Losses," contains interesting data. Also, the booklet, "Nonferrous Ingot Metals of Today." Write for both. They are free.

Successful foundrymen deoxidize or "clean up" molten metal by a scientific method worth using as indicated:

They use phosphorus . . . expertly . . . in the form of "Ajax Phosphor Copper" . . . added as the crucible is removed from the furnace . . . for virtually all brass and bronze alloys.

In notched waffle sections, or in shot form, Ajax 15% P-Cu does its work at .01% (1 oz. per 100 lbs.). Introduced, and having time to react when stirred with a whirling motion of the skimmer, it causes oxides to rise for effective removal by skimming from the surface. It is best to avoid phosphorus build-up from back stock.*

If you use phosphorus these days, use Ajax phosphor Copper (useful also in producing your phosphor bronze).

SINCE 1880

AJAX METAL COMPANY PHILADELPHIA 23, PA.

ASSOCIATE COMPANIES

AJAX ELECTRIC CO. • AJAX ELECTROTHERMIC CORP. • AJAX ELECTRIC FURNACE CO. • AJAX ENGINEERING CO.

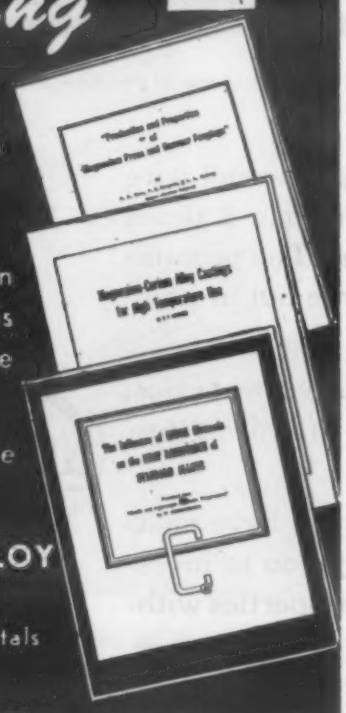
Are You Missing

any information about

CERIUM*

"The Influence of Minor Elements on Heat Resistance of Standard Alloys" is the latest addition to the Cerium File Folder. It is available on request.

Is your name filed with us to receive new publications, as issued?



*CERIUM STANDARD ALLOY

Containing 45-50% Cerium — Balance principally rare earth metals

Also available

CERIUM MASTER ALLOYS

CERIUM METALS CORPORATION

522 FIFTH AVENUE • NEW YORK 18, N.Y.

News of...

ENGINEERS COMPANIES SOCIETIES

conducting a drive to hire 1540 additional men and build up night shifts. The drive is part of the company's $38,800,000 expansion program.

The *Arseneau-Price Co.*, 10840 E. Warren Ave., Detroit 13, is a new company that will manufacture a complete line of standard straight shank chucking reamers and other types of reamers, all made of 18-4-1 steel and heat-treated by the electric salt bath method.

The name of the *Aircraft Screw Products Co., Inc.*, Long Island City, N. Y., is changed to *Heli-Coil Corp.* since its products are now used widely outside of the aircraft industry.

What is claimed to be the largest ponderosa and sugar pine plywood plant in the U. S. will be constructed by *United States Plywood Corp.* and *Harbor Plywood Corp.* at Anderson, Calif. It will have a capacity of 6,000,000 ft. per month.

The *Linde Air Products Co.* is constructing an oxygen filling station and acetylene-producing plant at Creve Coeur, near Peoria, Ill., to be ready for operation Jan. 15.

A new and dramatic industrial exhibit, designed and built by *General Motors Corp.* graphically to portray the 50-year story of the development of the automobile, has been opened at the Chicago Museum of Science and Industry. Called the "Motorama," many of the things shown are animated. For instance, by means of push buttons the visitor can start any one or all of the eleven types of historic wheels rolling on specially designed axles.

The *Calumet & Hecla Consolidated Copper Co.* will provide a four-year scholarship in either mining or metallurgical engineering at the Michigan College of Mining & Technology of Houghton.

Micromatic Hone Corp. has completed and occupied a new 38,000 sq. ft. addition to its main plant at 8100 Schoolcraft, Detroit 4.

The *James F. Lincoln Arc Welding Foundation* has made its first grand award of $13,200 in its Design-for-Progress Award program to members of the Aeromatic Propeller Dept., *Koppers Co., Inc.*, Baltimore, for their paper, "Development of Arc Welded Propeller Hubs."

A fully mechanized steel distribution warehouse, costing over $200,000, has been opened by *Crucible Steel Co. of America* at Primos, Philadelphia.

Superior Steel Corp. has ordered a new 3-high roughing mill from the *Lewis Foundry & Machine Co.* for use at Carnegie, Pa. Superior's $1,500,000 program

Look at these 9 Important Advantages of Du Pont ACCELERATED SALT WS*

*WATER SOLUBLE

FREE WASHING

EXCELLENT carburizing activity	No sludge formation
NO BAIL-OUT	MINIMUM LOSS in heat radiation and fuming
EXCELLENT FLUIDITY	CONVENIENT 1 oz. pellets (NO DUSTING)
Low molten density	Simple bath control

TRY IT for producing intermediate cases. You'll find it has excellent carburizing activity over a wide operating range, 1500°F. to 1650°F. You'll find it easy to use, easy to get results. And best of all, you'll like the ease and speed in cleaning treated work—the thorough removal of all salts by simple washing. For both the salts composing the bath and the decomposition products are completely water soluble. There is no precipitation of water insolubles even with detergents which may be used in cleaning oil-quenched work.

PRACTICAL TECHNICAL SERVICE: Experienced advice and technical assistance in the application of Du Pont Accelerated Salt WS or the selection and use of other Du Pont heat-treating materials is freely available. Just call or write the nearest Du Pont office.

E. I. du Pont de Nemours & Co. (Inc.), Electrochemicals Dept., Wilmington 98, Delaware.

District Offices: Baltimore, Boston, Charlotte, Chicago, Cincinnati, Cleveland, Detroit, El Monte, Calif., New York, Philadelphia, Pittsburgh, San Francisco.

Tune in to Du Pont "Cavalcade of America" Monday nights—8 P. M., EST, NBC.

DU PONT
REG. U. S. PAT. OFF.

BETTER THINGS FOR BETTER LIVING...
THROUGH CHEMISTRY

DU PONT
ACCELERATED SALT WS
The FREE WASHING Carburizing Compound

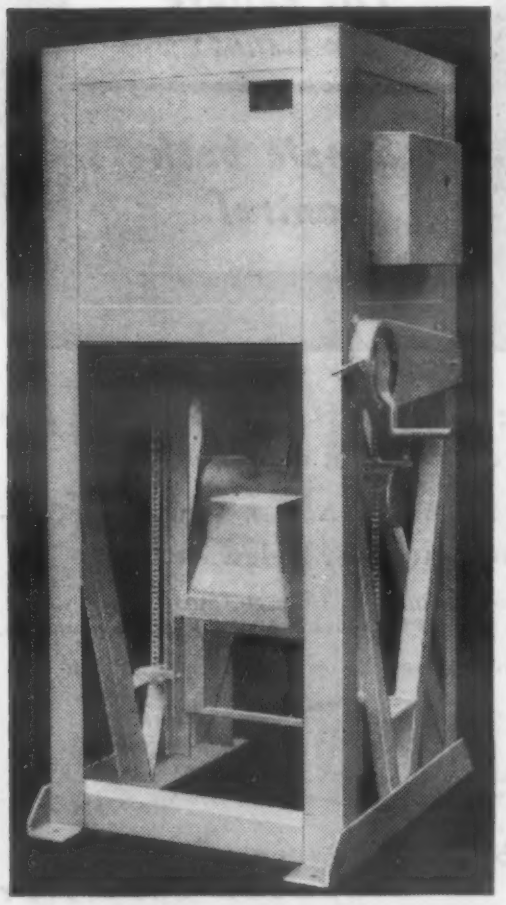
QUESTIONS AND ANSWERS ABOUT

Harper

ELECTRIC FURNACES

Who builds Harper Electric Furnaces?

Harper Electric Furnaces are individually designed by engineers who have specialized on high temperature electric furnace construction for many years. A thorough knowledge of the importance of correct balance between heating elements, refractories, temperature control and other requirements for uniform, accurate temperatures results in satisfactory performance.



The above furnace has an elevating hearth for test-melting in crucibles, firing ceramic samples and other research. Write for data.

Harper

ELECTRIC FURNACE CORPORATION

1461 Buffalo Avenue
Niagara Falls, N. Y.

Representatives in Principal Cities

News of...

ENGINEERS COMPANIES SOCIETIES

involves improving the quality of hot-rolled products and increasing the width of clad metals. The new mill will operate by Jan. 1, 1949.

Societies

This year will be a record one for trade shows and expositions, according to the *Exhibitors Advisory Council, Inc.,* New York, with 21 years' experience. The listings in the 1948 schedule, covering all types of events—trade, industrial, professional, etc.—total 718 for the first eight months of the year, against 468 for the same period of 1947, an increase of over 53%.

United States engineers will join with those of South America and Canada in a *Pan-American Engineering Congress* to be held in South America, possibly Bogota, Columbia, late in 1948 or in 1949. It will be sponsored by the Engineers' Joint Council Committee on International Relations, 29 W. 39 St., New York. Participation will be recommended to all constituent societies, including civil, mining and metallurgical, mechanical, electrical and chemical engineers.

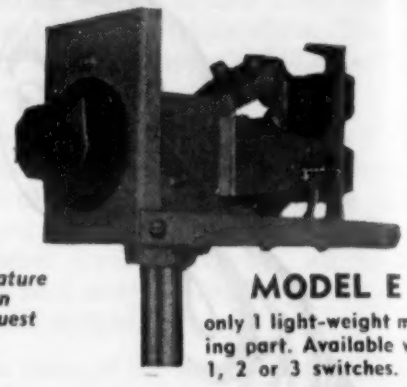
Quality control test procedures for castings plants will be the subject of a special series of lectures at the 1948 foundry congress and show of *American Foundrymen's Assn.* in Philadelphia, May 3-7. Recommended practices for brass, bronze and nickel alloys; gray iron; light metals; malleable iron and steel will be analyzed.

William M. Goss, vice president, Scovill Mfg. Co., Waterbury, Conn., has been elected president of the *Copper & Brass Research Assn.* Other officers elected were: Vice presidents, H. W. Steinkraus, president, Bridgeport Brass Co.; S. H. Perry, general sales manager, Chase Brass & Copper Co., Inc.; G. D. Stearns, president, Bridgeport Rolling Mills Co.; and A. C. Wheeler, vice president, Seymour Mfg. Co. F. L. Riggin, president, Mueller Brass, was named treasurer; T. E. Veltfort, manager, and Bertram B. Caddle, secretary.

The *National Assn. of Metal Finishers, Inc.,* is devoting special attention to the problem of waste disposal, many platers having been blamed for pollution of streams and sewers by dumping poisonous materials without pre-treatment. Thus, a Michigan concern dumped 3600 gal. of solution containing cyanide into a common sewer, putting out of commission the water purification system. As yet, no standard set of procedures for the industry

BURLING TEMPERATURE LIMIT SWITCHES

USE NO LIQUIDS . . . NO GASES



Literature on Request

MODEL E

only 1 light-weight moving part. Available with 1, 2 or 3 switches.

As a 3 switch model, Burling Model E is recommended for use (a) where load is divided into 3 parts, (b) where 1 switch is used for controlling, one as a high limit, one as a low limit, (c) to give definite stops or position to a 3 or 4 position diaphragm motor, (d) to give 3 speed control of variable speed motor.

- **Accurate, Rugged, Dependable**
- **Corrosion and heat resisting tube**
- **Dial Pointer for easy setting**
- **Locking screw locks temperature setting**
- **Terminal plate has large screw terminals**
- **Snap-action Micro-Switch eliminates contact troubles**
- **Increased Adjustable range to 700-1000°**
- **Dimensions—7¼" x 2¾" x 3½"**

MODEL V-I

For lower temperature range from 0-300°F. Available for minimum of —100° to maximum of 600°F. Usual adjustable range 50-150°, operating differential may be as small as ±¼ or as large as ±5°. Adjustable by screw and dial inside case. (Sizes 2¾" diameter × 4¼" high.)

MODEL D

Adjustable range 200-500°F. Temperature range 0-1400°F. For use where temperature must be changed to suit operating conditions. Turn outside knob to change temperature setting. (Sizes 5½ x 2¾ x 2¾".)

Instruments also Built to Specifications

Making Precision Controls for Over 11 Years

BURLING INSTRUMENT CO.
Springfield Ave. at Livingston St.
Newark, N. J.

What's in Back

OF THE BEST HAIRBRUSHES

and why?

There's more to a good hairbrush than just the bristles!

The brush block, the handle, the design and color all contribute to the final result. . . . the right material is the key to hairbrush quality and long wear, especially when the right material is the economical material. That's why Lumarith* is being used in increasing quantities by big name brush manufacturers.

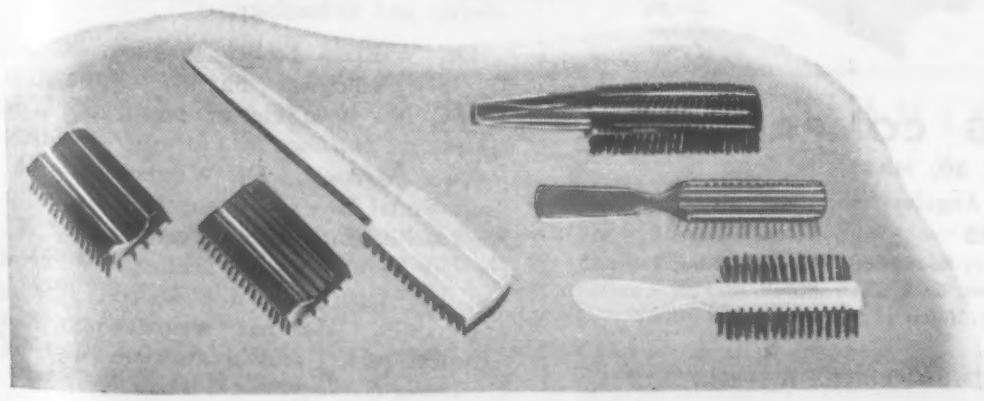
Lumarith:

is unexcelled for color transparency
can be molded in heavy cross sections
does not fracture or craze when drilled or machined
gives excellent bristle retention
is chipproof and splitproof
is resistant to hot water
is not affected by hair oils and dressings

Are these Lumarith qualities the same qualities you need to make your product a better one? If you're making a personal use item, an appliance, a housing, a toy or a household product, consider the advantages of using Lumarith or one of the other tough Celanese* cellulosic plastics.

SEND FOR "THERE'S A RIGHT PLASTIC FOR EVERY JOB"

CELANESE CORPORATION OF AMERICA,
Plastics Division—Dept. D-4
180 Madison Avenue, New York 16, N. Y.



Brushes of Lumarith are molded by . . Fuller Brush Co., Pro-Phy-Lac-Tic Brush Co., Vulcanized Rubber & Plastics Co., Tek-Hughes, Inc. and Gibson-Thomsen Co., Inc.

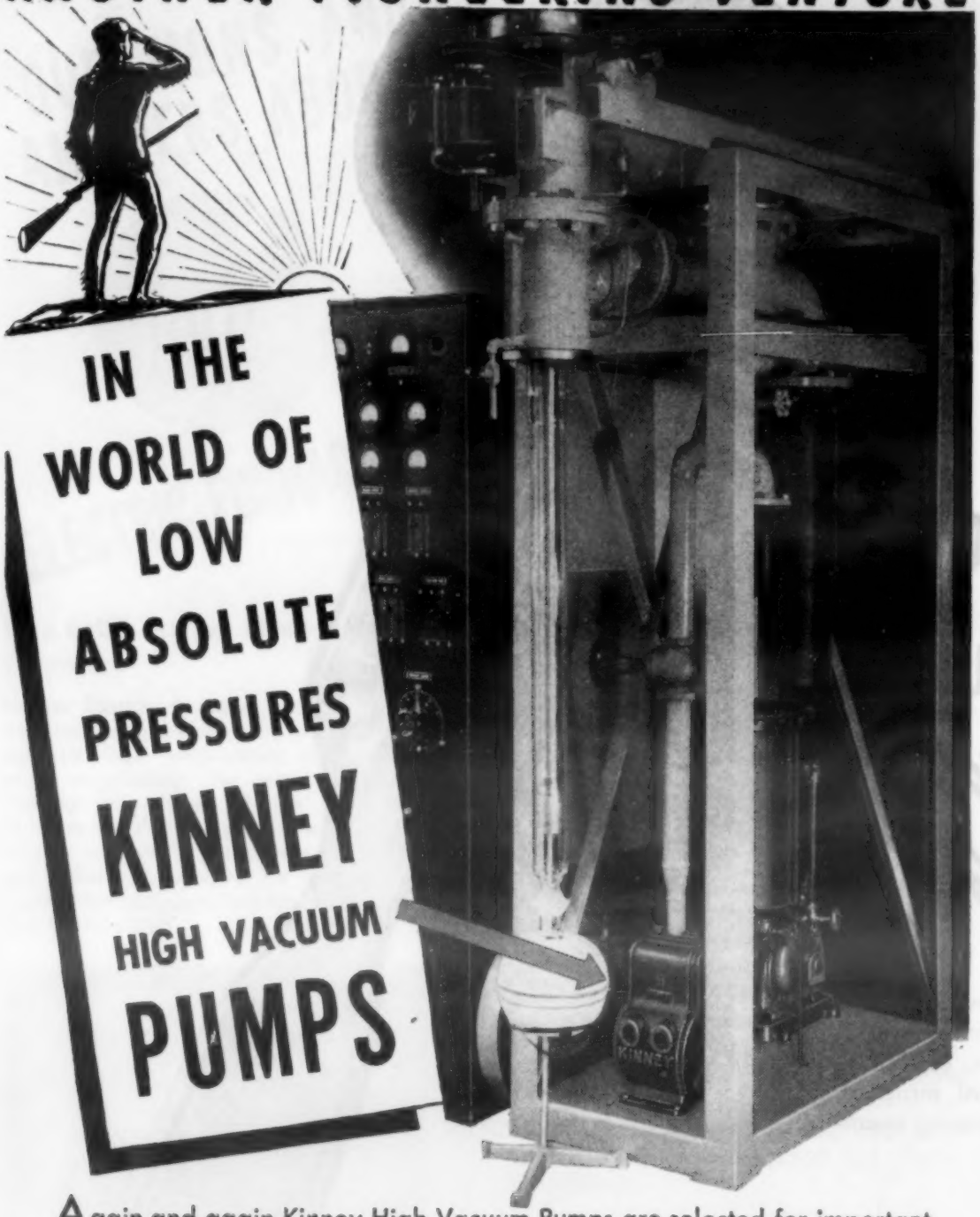
LUMARITH*

*Celanese** **CELLULOSIC PLASTICS**

LUMARITH* FORTICEL*
CELLULOID* VIMLITE*
CELCON*

*Reg. U. S. Pat. Off.

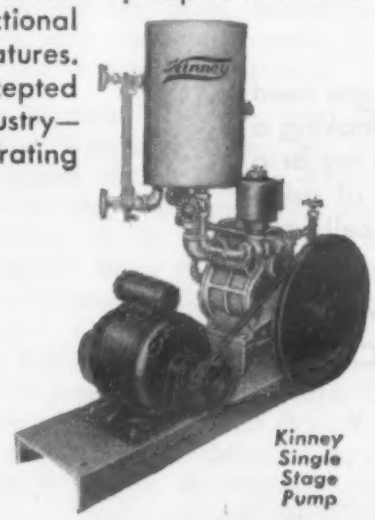
ANOTHER PIONEERING VENTURE



IN THE WORLD OF LOW ABSOLUTE PRESSURES

KINNEY HIGH VACUUM PUMPS

Again and again Kinney High Vacuum Pumps are selected for important projects in the ever-widening field of low pressure processing. In this new high vacuum Rotary Fractionating Still, manufactured by National Research Corporation, Cambridge, Mass., the Kinney Vacuum Pump is an integral part of the compact unit and backs a diffusion pump to maintain extremely low absolute pressures for the fractional separation of liquids at relatively low temperatures. Kinney High Vacuum pumps are widely accepted for dependable low pressure processing in Industry—from exhausting lamps and tubes to dehydrating food, producing drugs, sintering alloy metals and performing countless other operations. Their compact design saves floor space and their rapid pump down to low ultimate pressures shortens production time. Kinney Single Stage pumps create and maintain low absolute pressures to 10 microns; Compound pumps to 0.5 micron.



Kinney Single Stage Pump

Write for Bulletin V45

KINNEY MANUFACTURING COMPANY

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FOREIGN REPRESENTATIVES

GENERAL ENGINEERING CO. (RADCLIFFE) LTD., Station Works, Bury Road, Radcliffe, Lancashire, England

HORROCKS, ROXBURGH PTY., LTD., Melbourne, C. 1. Australia

W. S. THOMAS & TAYLOR PTY., LTD., Johannesburg, Union of South Africa

WE ALSO MANUFACTURE LIQUID PUMPS, CLUTCHES AND BITUMINOUS DISTRIBUTORS

News of...

ENGINEERS COMPANIES SOCIETIES

has been outlined for neutralizing waste. A committee to study the matter has been appointed.

The third instrument conference and exhibit of the *Instrument Society of America* will be held in convention hall, Philadelphia, Sept. 13-17. It will be known as the American Instrument Fair and will occupy 200 booths on the arena stage. There will be the usual technical sessions and several related societies will participate. Some 15,000 registrations are expected.

An annual award for distinguished achievement in the field of ceramics has been established by the Pittsburgh section of the *American Ceramic Society*, known as the Albert Victor Bleininger Memorial Award. The late Dr. Bleininger was a charter member of the American Ceramic Society and extremely active in its affairs.

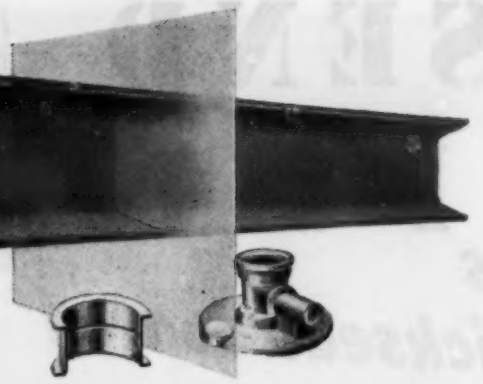
The annual meeting of the *Pressed Metal Institute* will be held at the Hotel Statler, Buffalo, Feb. 10 and 11, and will be devoted to reports of officers and committee chairmen, election of trustees and officers, and four programs for management and stamping engineers. Jerry Singleton has been appointed assistant to the president of the Institute. He has had over 20 years experience in contact work with trade associations, and will assist in organizing new district groups and in securing new members.

The *American Electroplaters' Society* is changing the name of its publication, *The Monthly Review*, to *Plating*, as a more descriptive word of its coverage. It will change its size from the pocket size to the standard industrial paper dimensions of 8¼- by 11¼-in. page size.

A Chicago technical and scientific center has been established through an alliance between the *Western Society of Engineers* and the *John Crear Library*. Three floors in the Taylor building which adjoins Crear on Randolph St. have been leased. Offices, conference rooms and an auditorium holding 300 will be included in the center, which will cover 9000 sq. ft. of floor space. The Western Society's collection of 20,000 books will be coordinated with the 700,000 volume Crear library, the world's largest free public library devoted exclusively to science and technology.

Dr. William Embry Wrather, director, U. S. Geological Survey, Washington, D. C., has been elected president of the *American Institute of Mining & Metallurgical Engineers*. Dr. Wrather started his professional career as a petroleum geologist. He reached his present position in 1943. He has been a special geology lecturer at geology departments of several leading universities. He has written numerous technical papers and is associate editor of *Economic Geology*.

FOR DEPENDABILITY



... Specify "GENERAL CHEMICAL"

CHEMICALS FOR THE METAL INDUSTRIES

Acetic Acid
Ammonia Alum
Ammonium Thiosulfate Solution
Aqua Ammonia
Chromium Fluoride
Fluoboric Acid
Hydrofluoric Acid
Hydrogen Peroxide
Metal Fluoborate Solutions
Muriatic Acid
Nitric Acid
Potash Alum
Potassium Cyanide
Sodium Fluoride
Sodium Metasilicate
Stannous Chloride
Sulfuric Acid
Tetrasodium Pyrophosphate
Trisodium Phosphate

Rimming Steel Manufacture
Sodium Fluoride

Steel Manufacture
Sodium Bisulfite, Anhydrous
Sodium Sulfite, Anhydrous
Sulfur
Iron Sulfide

Descaling
Glauber's Salt
Sulfuric Acid

Acetic Acid
Hydrofluoric Acid
Muriatic Acid (Hydrochloric)
Nitric Acid
Sulfuric Acid
Nitre Cake
Sodium Fluoride
Sodium Bifluoride

Casting
Ammonium Fluoborate
Potassium Fluoborate
Sodium Fluoborate

Barium Fluoride
Sodium Fluoride
Potassium Fluoride
Potassium Cyanide

Electrolytic Polishing
Acetic Acid
Perchloric Acid
Sulfuric Acid
Hydrofluoric Acid

Bright Dipping
Hydrofluoric Acid
Nitric Acid
Sulfuric Acid
Muriatic Acid (Hydrochloric)

Oxide Finishing
Copper Sulfate
Hydrofluoric Acid
Nitric Acid
Oxalic Acid
Sodium Silicate
Sulfuric Acid

Galvanizing
Sodium Fluoride
Hydrochloric Acid
Sulfuric Acid

ALKALI CLEANING
Aqua Ammonia
Sodium Silicate
Trisodium Phosphate (TSP)
Tetrasodium Pyrophosphate, Anhydrous
Sodium Metasilicate

FOR METAL ANALYSES
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LABORATORY REAGENTS
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BASIC CHEMICALS
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SEND FOR

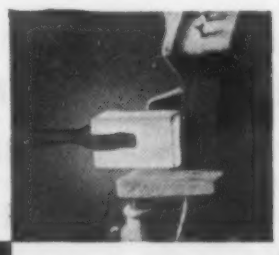
this ***Brickseal coated***

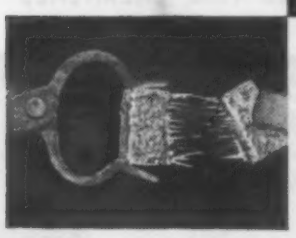
BRICK

Brickseal penetrates the pores and joints of firebrick and forms a highly glazed ceramic coating many times harder than the brick.

Tough and semi-plastic under heat, it prevents cracking and spalling regardless of temperature change—heat the sample and douse in cold water any number of times.

Brickseal resists abrasion. Force the sample brick, either hot or cold, against an emery wheel and see the difference on the coated and uncoated sides.





Brickseal is a superior mortar for fire walls. Try to pull the sample bricks apart after they are heated to 2200°.

Write today for a free sample. No obligation, of course.

Brickseal

REFRACTORY COATING

5800 So. Hoover Street, Los Angeles, Calif.
158 - 14th Street, Hoboken, New Jersey

News of...

ENGINEERS COMPANIES SOCIETIES

A clinic for plastic molders and fabricators is being held Jan. 21 and 22 in the main auditorium of the Engineers' Building, 29 W. 39 St., New York, sponsored by the *New York State Department of Commerce* and *Brooklyn Polytechnic Institute.* The first day will be devoted to various plastics materials, while subjects the second day will concern laminates, low pressure molding, recent advances in techniques, distribution and marketing, and the future of plastics. Admission is by invitation only from the Dept. of Commerce, Bureau of Industry, 112 State St., Albany 7, N. Y.

The first issue of *Applied Mechanics Reviews,* a new monthly engineering and scientific journal reviewing current worldwide literature on applied mechanics, will appear this month. Co-sponsors are the *American Society of Mechanical Engineers,* the *Engineering Foundation,* the *Illinois Institute of Technology* and other organizations. Dr. L. H. Donnell, research professor of mechanics at Illinois "Tech," is editor-in-chief.

The 1947 Gantt Memorial Medal of the *American Society of Mechanical Engineers* has been awarded to Alvin E. Dodd, president, American Management Assn., for "distinguished achievement in industrial management as a service to the community."

The *National Foundry College* has been established in Great Britain, succeeding the British Foundry School, inaugurated in 1935 and closed in 1939. The new college began its first session Jan. 5 at Wolverhampton.

Membership of the *American Society of Mechanical Engineers,* embracing 22,000 engineers, has elected E. G. Bailey, vice president. He is an authority on fuels, combustion and power developments, and an inventor, holding over 100 patents.

Southwest Research Institute, 1804 Milam Bldg., San Antonio 5, a non-profit scientific organization to aid Southwestern industry solve its technological problems, recently opened its laboratories and has contracted for several projects.

The *Metal Treating Institute* has elected R. G. Sault, vice president, Porter Forge & Furnace, Inc., Somerville, Mass., as its president.

The *Porcelain Enamel Institute* has elected as president C. D. Clawson, Ferro Enamel Corp., Cleveland.

The *American Welding Society* has elected Harold O. Hill as president. He is assistant chief engineer, fabricated steel construction, Bethlehem Steel Co.

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BOOK REVIEWS

Four New Books on Powder Metallurgy

POWDER METALLURGY. *By Dr. Paul Schwarzkopf. Published by the Macmillan Co., New York, 1947. Cloth, 6½ x 9½ in., 379 pages. Price $8.00.* Information about the industrial processing of metal powders and the products obtainable is given in this compilation of facts not only from the technical and patent literature, but also from the first-hand knowledge of the author in his experience in the industrial exploitation of powder metallurgical methods, and the theories and reflections on which he has based his own work.

Some of the chapters are: Metal Powders; Compacting; Sintering; Treatment Subsequent to Sintering; Interrelations between Powder Characteristics, Compacting, and Sintering Conditions; Dense Materials; Porous Products; Refractory Metals; Hard Metals; Theoretical Concepts. Latest developments and some future possibilities of the field are covered.

POWDER METALLURGY. *By Henry H. Hausner. Published by Chemical Publishing Co., Brooklyn, N. Y., 1947. Cloth, 5½ x 8¾ in., 307 pages. Price $7.00.* Principles of powder metallurgy explained in the form of tables and graphs, methods of manufacturing metal powders, and the commercially available metal powders and their applications are given. Shows the relationship between the physical properties of the metallic compact such as density, hardness, strength and electrical and magnetic properties and the variables of the powder metallurgical process. A glossary of powder metallurgical terms and a chronological bibliography are included.

ELECTRICAL CONTACTS. *By F. R. Hensel. Reproduced by Mapleton House, Brooklyn 4, N. Y., 1947. Heavy paper, 5¼ x 7¾ in., 24 pages. Price $1.00. Mimeographed.* Under the Joint Intelligence Objectives Agency a survey was made of German contact materials and manufacturing methods. Practices similar to those known in the United States are used in general. Composition, properties and production of contact alloys and the companies producing them are discussed. Describes methods used for bonding inlays and overlays to expensive metals.

POWDER METALLURGY. *By Alexander Squire. Reproduced by Mapleton House, Brookyyn 4, N. Y., 1947. Heavy paper, 5¼ x 7¾ in., 170 pages. Price $8.00. Mimeographed.* Information based on experiments made between 1944-1945 in the Watertown Arsenal Laboratories is given in nine parts. Some of these reports are: Comparative Properties of 0.55 Carbon Steel Bars Formed by Conventional and Powder Metallurgy Methods; Critical Survey of Powder Metallurgy and Its Application in Ordnance Design; Evaluation and Correlation of the Quality Characteristics of Powdered Iron Compacts; Iron Graphite Powder Compacts; and Effect of Dimensions Upon the Density and Mechanical Properties of Iron Powder Compacts.

Other New Books

CHEMICAL AND TECHNICAL STENOGRAPHY *By James Kanegis. Published by James Kanegis, P. O. Box 1121, Washington 13, D. C., 1947. Cloth, 5½ x 8½ in., 388 pages. Price $5.00.* For stenographers dealing with chemistry, metallurgy, mathematics, physics, electricity, general science and some phases of engineering and industry. Contains new phrasing techniques, abbreviating symbols of applicability to all Gregg writers, and an extensive cross-referenced vocabulary of words, phrases and abbreviations. The text may be used for both teaching and self-study.

NONFERROUS PRODUCTION METALLURGY—SECOND EDITION. *By John L. Bray. Published by John Wiley & Sons, Inc., New York, 1947. Cloth, 6¼ x 9¼ in., 587 pages. Price $6.00.* Contains additional material on aluminum, copper, magnesium, nickel and tin. The application of physical chemistry to metallurgical processes is discussed and typical problems are solved. Brief remarks on the strategic position of this country have been added to each chapter.

PROCEEDINGS THIRD ANNUAL SPRING MEETING, METAL POWDER ASSOCIATION, NEW YORK, MAY, 27, 1947. *Published by Metal Powder Association, New York, 1947. Heavy paper 6 x 9 in., 70 pages. Free to members.* Eight papers prepared for this meeting are given. The subjects include: Stainless Steel Powder; New Developments in the Production of Metal Powder Parts; Cost Calculation in the Production of Powder Metallurgy Parts; Bearings, Bushings and Allied Products; Apparatus for Air Classification of Metal Powders; Copper-Lead Bearings from Metal Powder; Electrical and Electronic Components from Powdered Metals; and Metal Powders as Pigments.

SUPPLEMENT TO NATIONAL DIRECTORY OF COMMODITY SPECIFICATIONS. *Prepared by Charles A. Cooley. Published by Superintendent of Documents, Government Printing Office, Washington 25, D. C., 1947. Cloth, 322 pages. Price $2.25.* This Supplement, with the 1945 edition of the Directory, provides a listing by name, designating number, and issuing or sponsoring organization, of all the standards, specifications and methods of test in general use for commodities produced in or purchased by this country. Each specification, of which there are 44,000, is summarized as to technical characteristics, scope and special applications.